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CONTENTS

	Page
The Balance of Arts and Sciences in Education	1095
Essays on Science. By Dr. W. L. Sumner	1097
Virtuous Quarrels. By Dr. E. R. Leach	1098
Dictionary of Television and Radar Terms. By Dr. R. L. Smith-Rose, C.B.E.	1099
Spectroscopy at Centimetre Wave-lengths. By Dr. D. M. S. Bagguley	1099
Polynesian Tales in Poetry. By M. C. Burkitt	1100
Peaceful Uses of Atomic Energy. By Dr. T. E. Allibone, F.R.S.	1102
Ecology of *Anopheles gambiae* Giles. By James G. Halcrow	1103
The Abyssal Fauna : its Ecology, Distribution and Origin. By Dr. Anton Fr. Bruun	1105
News and Views	1108
The Growth of Leaves. By Prof. F. L. Milthorpe	1114
Freshwater Biology in Scotland	1115
Chemistry of Oxygenated Heterocyclic Compounds : International Colloquium at Lyons	1116
Animal Sounds in the Sea	1117
Chelating Agents as Plant Growth Substances : a Possible Clue to the Mode of Action of Auxin. By Dr. O. V. S. Heath and Miss J. E. Clark	1118
An Unorthodox View of the Weather. By Dr. E. G. Bowen	1121
Letters to the Editors :	
Hydrolysis of Esters of Monoribonucleotides.—D. M. Brown, D. I. Magrath, A. H. Neilson and Sir Alexander Todd, F.R.S.	1124
Ionophoresis of Oligosaccharides as N-Benzylglycosylammonium Ions.—Dr. S. A. Barker, Dr. E. J. Bourne, P. M. Grant and Prof. M. Stacey, F.R.S.	1125
Ion-Exchange Preparation of Low-Silica Hydroxide Solutions for Colorimetric Determinations of Total Silica.—Sallie Fisher and Robert Kunin	1125
Use of the Orcinol-Sulphuric Acid Reaction in the Positive Identification of Certain Monosaccharides from a Salivary Mucoid.—Dr. M. Irwin and Dr. A. G. Leaver	1126
X-Ray Mass Determination in Cells by Scanning.—Bengt H. O. Rosengren	1127
Some New Stereochemical Arrangements of Divalent Palladium and Platinum.—Dr. C. M. Harris, Prof. R. S. Nyholm and N. C. Stephenson	1127
Cation-Exchange Properties of Zirconium (IV)–Tungsten (VI) Precipitates.—Kurt A. Kraus, Thomas A. Carlson and James S. Johnson	1128
Composition of Egg Phospholipids.—Dr. D. N. Rhodes and Dr. C. H. Lea	1129
Characterization of an Enzyme reducing Pyrroline-5-Carboxylate to Proline.—Marion E. Smith and Prof. David M. Greenberg	1130
Effect of Reserpine on Serotonin in Rabbit Serum—Knut Naess and Mrs. Susan Schanche	1130
Oxidation of Octanoic Acid by Cell-free Bacterial Extracts.—S. Dagley	1131
Bacterial Variation to Sensitivity : an Example of Individuality in Micro-organisms.—Dr. W. Howard Hughes	1132
Free Amino-acid Content of the Lymph.—P. Braun, M. Földi, S. Kisfaludy and Gy. Szabó	1133
Reciprocal Egg Transplantations to study the Embryo–Uterine Relationship in Heat-induced Failure of Pregnancy in Rabbits.—Dr. M. K. Shah	1134
Determination of Sex in Early Human Embryos.—Dr. T. W. Glenister	1135
Effect of Electric Shock and Cardiazol Shock on Morphine Tolerance.—Y. Kasé	1136
Hair-line Cracks in Low-alloy Steels.—A. Barker and A. Wainwright	1136
Dependence of Snowfall on Temperature.—L. W. Gold and G. P. Williams	1137
Results of Gravitational Significance in Riemannian Geometry.—Prof. V. V. Narlikar	1138

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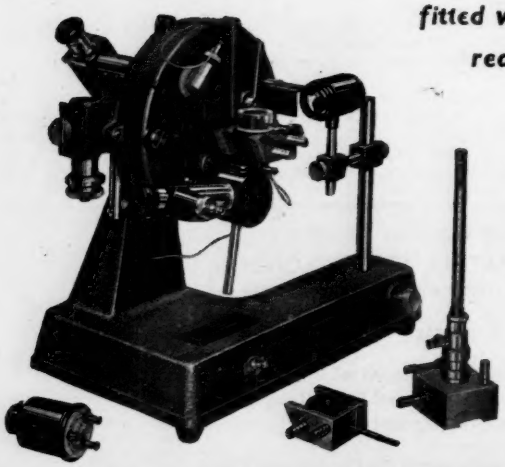

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THE BALANCE OF ARTS AND SCIENCES IN EDUCATION

SPEAKING at the North-western Management Conference at Southport on March 19 of the need in industry for students of the humanities, Mr. D. R. O. Thomas urged that, to meet the advances in science and technology, and changes in the technique of control and communication which electronics is bringing about, we need men who are responsive to ideas over a wide front and who are capable and ready to accept responsibility with courage and decision. Without such men who can appreciate scientific method and the nature of scientific ideas as well as the humanities, efficient organization and administration are scarcely possible to-day; nor are we likely to deploy to the best advantage our present limited numbers of scientists, technologists and technicians, let alone achieve the larger number that Great Britain requires. Whether, like Mr. Thomas, we are primarily concerned with the training of managers, or, like Dr. D. S. Anderson, addressing the Northern Counties Technical Examinations Council, our concern is chiefly with the expansion of the technical colleges and colleges of technology, or whether our concern is with the shortage of scientists or the function of the universities in this age of nuclear power and the electronic computer, we are brought face to face with the question of general education and the need for a balance between science and the humanities, both in the training of the scientist and technologist and in that of the administrator and man of affairs.

This is indeed the central problem which has to be faced in planning the expansion of university and technological education as well as of technical education, and no allocation of resources of materials and finance which ignores it will suffice. We have to make up our minds what we mean by general education in this context—how and where it should be given—and not merely formulate adequate proposals but also take effective measures to give effect to them. It is idle to hope that the situation will improve of itself. It is more likely to deteriorate. Even from the point of view of science alone, Dr. Robert Oppenheimer, speaking to the American Institute of Physics on February 2, expressed the view that the pioneer conceptions which led through Einstein to the splitting of the atom are now inadequate to yield an orderly description of the physical world. Dr. Oppenheimer is not confident that the man or woman who can rescue us from the rich disorder of our new knowledge will speedily appear; but he believes that he or she is likely to be a young natural scientist. It is even more probable that he or she will be someone able not merely to interpret the nuclear scientist to fellow natural scientists, but equally to set that new knowledge in the context of biological science and of the humanities.

It is important, therefore, that full support should be given to what is already being done in Britain to encourage movement or transfer from the arts side to science, both on the part of those just leaving school and also within the university. The fifty scholarships endowed by Imperial Chemical Industries, Ltd., for those leaving school who wish to transfer from the humanities and enter the universities to train as scientists is a welcome step; but it is an example which needs to be followed by the universities themselves, as well as by the Ministry of Education and the local authorities. For a time it will only touch the fringe of one problem; but it could demonstrate the value of such a transfer, and the cumulative effect may be invaluable. It is no substitute, however, for the fundamental thought about the content of courses and balance of studies, the hard work that may be involved in replanning complicated time-tables and the fundamental questions as to the respective purpose or functions of university, college of technology and technical college.

That challenge is, however, already being met. Sir Eric Ashby and Prof. K. Denbigh have recently directed attention to the place of the humanities in technology and suggested that technology can, in fact, be taught as an essential element in a liberal education and one which makes for social coherence. Pointing out that human interests and sympathies are even more to be desired in the technologist than in scientific workers in the laboratory, Prof. Denbigh has stressed the real need to-day for technologists who are good at their speciality but who have an equal interest in management, and emphasized that because of his human responsibilities and contacts the technologist needs imagination and something of the outlook of the humanist. He puts the intellectual value of technology rather with that of economics, psychology or medicine, and suggests that, rightly presented, it should appeal to the boy or girl whose school work is in the humanities. Still more recently, Prof. C. W. Dannatt, in his presidential address to the Institution of Mining and Metallurgy on May 17, in discussing the educational value of technological studies, claimed that they provide the discipline and training essential to culture; but he indicated also the problems that require attention if they are to develop that full educational value.

The demonstrable value of the humanities, properly taught, to the future administrator should make us take care that the administrator of to-day, in acquiring the understanding of science and technology that he needs, preserves that element; but equally the scientist intended for managerial responsibilities should be given full opportunity of acquiring it. Here, as Prof. Denbigh points out, there is room for more constructive thought about the assimilation of technology into the social structure. Training for leadership bears closely on leadership in a technological society, and the problems of technological change and the adaptation of society to innovation.

If, however, any considerable changes are to be made in the content and balance of university and technical college courses, there must be widespread

public understanding of the reason for those changes. The Government has indeed recognized in the White Paper on Technical Education that, without the support and understanding of parents, we can scarcely expect to obtain the considerable increase in the number of students of technology that is required. This is no less true of any increase in the number of scientists, and the growing dependence of the universities on public support makes it essential in regard to changes of policy. The academic freedom and autonomy of a university can only be preserved if their importance is clearly understood by those from whom ultimately its resources are mainly drawn.

This is one reason for welcoming the further number of *The Twentieth Century* devoted to the universities, which appeared in February. Although this issue was concerned solely with the so-called civic universities, it is well calculated to further the public understanding and the respect for learning and pursuit of truth by the governing elements in Britain which are the ultimate guarantee of academic freedom in any society. Moreover, the symposium is far from being a survey and comparison of the provincial universities: their weaknesses as well as their achievements are assessed, and many points are indicated on which searching inquiry as well as constructive thinking should be proceeding if the universities are to make their fitting contribution to the expansion of technological education or in meeting the needs of the increased number of those leaving school which will be seeking admission in the next ten years.

Principal P. S. Noble, for example, who is confident that, despite increasing dependence on government support, academic freedom is not seriously endangered because the mutual understanding and respect between the universities and governing circles is likely to continue, points out that economic conditions will none the less determine whether we can continue to expand facilities and maintain standards. Nor can we yet assume without question that there is a considerable untapped reservoir of talent, or that there is not already in the universities of Britain at the public charge a considerable number of students who for lack of ability or other reasons are unfitted for university education. Indeed, Prof. J. Simmons is frankly dubious on this point. He does not believe that the standard of ability is declining; but he considers that students enter universities less well prepared than in the past, less widely read and often inadequately grounded in such fundamentals as the use of the English language. This, Prof. Simmons remarks, wherever the responsibility lies, tends to lower the standards of university teaching; and he sees another and more insidious threat to academic standards in the tendency of some students to regard as of right—not as a privilege to be earned—the assistance which some three-quarters of university students in Britain now receive in one way or another from public funds. Such an attitude may well prevent the student from deriving the full advantage of a university education, and quite apart from its inhibiting effect on the effort he puts into his studies, it may well blind the student as to the real purpose of a university education.

That at least is something which needs to be more clearly and generally understood, not merely by the student but also and more especially by those concerned with the planning of university expansion, and not least when that expansion is being considered in relation to some particular need such as technology. This symposium throws little light on that purpose. Prof. Simmons reminds us that the advancement of learning is the central task of all universities, and he is clearly concerned that over-anxiety to raise the standards of teaching may lead the civic universities to press their teachers so hard as to hinder the continuation of the notable contribution to learning which, collectively, they have made.

Prof. Simmons's uneasiness is reflected in Arnold Kettle's impressions of Leeds. He, too, comments on the comparative illiteracy which often characterizes first-year students in their inability to write coherent sentences, to read with pleasure a good book and their ignorance of history. An appreciable proportion of successful scholarship candidates, he maintains, are intellectually ruined by the process of cramming and pseudo-specialization which the present scholarship system induces in the grammar schools. But his statement that, in the only provincial university he knows well, probably most of the students are completely lacking in intellectual interest is not just depressing; it is as much an indictment of the teaching as an indication that students are unfitted for a university course. Mr. Kettle's impressions are undoubtedly disturbing. He doubts whether the provincial universities of Britain are yet in any really valuable sense civic or regional universities, and he has some comments on the tendency to stress the technological and vocational aspects of university education which are highly pertinent to the present discussion on the expansion of technical education. We can only impart to our students the broad-mindedness that is so desirable by teaching any and every subject from a fully humane and non-dogmatic point of view with sufficient emphasis on its origins, purposes and implications.

Nor is Mr. Kettle the only contributor who fears that the provincial universities are at present great purveyors of the mediocre. The symposium as a whole suggests that there is a good deal of disquiet as to conditions and standards, of which note should be taken before setting the pattern for further expansion over the next decade. There are indications of particular problems such as the proper relation between the arts and the sciences, to which more thought will clearly have to be given by the arts side as well as by the scientists. Alasdair MacIntyre, writing on the modern universities and the English tradition, suggests that the inadequacy of the provincial universities arises from the lack of any clear conception of what the significance or purpose of university life is. This ultimately derives from the loss of the moral tradition which guided English provincial life for many decades and in which the provincial universities were founded.

But it is not simply to the need for more constructive but fundamental thinking about the purpose of university life that this symposium points. Equally, as Mr. Kettle observes, we need an overall educational perspective in the school and university systems of Britain. Far more important than concern with the alleged decline in academic standards is the attack on the vast problem of improving the educational system as a whole, and Mr. Kettle thinks that university people would be wise to use more of their influence in trying to further that attack.

That is the only way in which Britain can deploy to the best advantage the limited resources in man-power, finance, equipment and building which it can devote to education. Unless those resources are planned as a whole, particular shortages like that of science teachers will continue to exert an effect out of all proportion to their real magnitude and to defy any speedy adjustment except at high cost. Particularly should the expansion of technical and technological education be planned in relation to one another, as well as in relation to the need for trained man-power and in relation to university education as a whole, and to the conditions and needs of secondary education in the grammar schools, the technical schools and the modern schools.

This, however, is the weakest spot in the Government's proposals. Thus far the Government has consistently refused to approach the question as a whole, and has persisted in dealing with each problem piecemeal and in isolation. This is the burden of Mr. John Wellens's paper on technical education and the shortage of scientists, technologists and technicians (see *Nature*, May 26, p. 967). He insists that we have not even yet the knowledge on which to satisfy ourselves that even the measures so far proposed are likely to be effective, and in particular he criticizes the White Paper for evading the re-examination of the place of the technical school in the educational system of the country. Moreover, like Sir Francis Simon and others, including Mr. A. K. Brown, in his presidential address on May 20 to the Association of Teachers in Technical Institutions, he urges the importance of establishing a body like the University Grants Committee, competent not merely to ascertain the facts but also to secure the concerted policy and action that the national interest demands, and too authoritative and informed to overlook dangers attending the scheme of the National Council for Technological Awards for a diploma of technology.

Whether the Parliamentary and Scientific Committee or any other body will be able to put effective pressure on the Government remains to be seen; but the promised debate on the White Paper on technical education offers an opportunity which should be used to the full to explain what is involved in a national policy and the points on which further information is required as a matter of urgency. Mr. Wellens's paper provides one good starting-point; but there are many others. Moreover, while the universities are formulating their own plans for the expansion of their technological departments, Prof. J. L. Montrose's presidential address on May 25 to the Association of University Teachers shows that university teachers themselves are alive to the qualities required to ensure that technology or any other subject is carried out at a university-level, and that some fresh thinking is already proceeding both as to the purpose of a university and the functions of a department of technology and the content of its studies. Likewise, the trend of the discussions at the Conference of the Universities of Great Britain and Northern Ireland last December, both on the passage from the school sixth form to the university and on the age-group bulge and its possible effects on university policy, indicates that, in the universities and also in the schools, an attempt is being made to think out a common policy and to consider it against the educational needs of Britain as a whole rather than the interests or traditions of particular universities or schools.

The widespread debate that is thus already proceeding should help to form a public opinion alive to what is involved, and prepared to make the sacrifices that a concerted educational policy on the necessary scale will demand. There must, however, be no relaxation of effort on the part of professional associations of technologists, university teachers and of educationists generally to make sure that those issues are clearly understood, and that defects in the Government's proposals are firmly indicated and explained without ambiguity. But above all there must be an increasing disposition not merely to look at university and technological and technical education as part of a national educational policy, but rather to subordinate sectional and local interests to national needs.

ESSAYS ON SCIENCE

What is Science?

Edited by James R. Newman. Pp. viii+493. (New York: Simon and Schuster, Inc., 1955.) 4.95 dollars.

THIS is a symposium of twelve chapters each specially written for the book. The editor, already known as the co-author of "Mathematics and the Imagination" and other works, has done his work well and writes engagingly about his intentions. His claims concerning the book are honest, have been fulfilled and are worth quoting: "Though written for persons without special training, the pieces in this book are not always easy. Neither is modern science. A decent respect for the reader requires that he be told when a subject admits of no further simplification; the contributors have not pretended to explain what cannot be explained. Nevertheless, every effort has been made to speak plainly, to refrain from jargon and nebulous profundities, to enlighten rather than astound. Although some areas are too difficult for any deep explorations, the nature of the problem, the aims of its investigations and the instruments they use have been made clear". If some of the book is not easy reading, any expenditure of effort on the part of the reader will be rewarding: the issues have not been avoided in an over-facile attempt to popularize science in terms of exciting superficialities.

The book is published in the United States; but more than half of the authors are British. The sections are as follows: science and human life (Bertrand Russell); mathematics and logic (the late Sir Edmund Whittaker); astronomy and cosmology (Hermann Bondi); physics (Edward V. Condon); chemistry (John Read); biochemistry (Ernest Baldwin); biology (the late Warner Clyde Allee); evolution and genetics (Julian Huxley); psychology (Edwin G. Boring); anthropology (Clyde Kluckholn); psychoanalysis (Erich Fromm); and science as foresight (Jacob Bronowski).

Bertrand Russell sets the stage for the subsequent contributors in his essay on the social relations of science. "It is to progress in the human sciences that we must look to undo the evils which have resulted from a knowledge of the physical world hastily and superficially acquired by populations unconscious of the changes in themselves that the new knowledge has made imperative. The road to a happier world than any known in the past lies open before us if atavistic destructive passions can be kept in leash while the necessary adaptations are made."

The late Sir Edmund Whittaker follows with a chapter on the nature of mathematics from the philosophical and logical point of view. This is timely and useful in view of the fact that so much mathematics is devoted to the niceties of internal arrangement.

Prof. Bondi discourses on the modern cosmologies and deals with the internal constitutions of the stars in terms of terrestrial physics. This is followed by an account of the problems of modern physics, with special reference to fundamental particles and waves, by Dr. Condon. Prof. Read's treatment of chemistry is historical, and he is followed by Prof. Baldwin, who surveys the field of modern biochemistry with special reference to human physiology.

The late Warner Clyde Allee has a short chapter on the nature of a living matter, as a prelude to an understanding of the human organism; and Dr. Huxley gives a short historical account of a century's work in evolution and genetics considered in the light of present-day human problems. "Through the new knowledge, the evolutionary process was able for the first time to become conscious of itself. The next decisive step in evolution will accordingly be the fuller development of that self-consciousness. In particular, it will be the conscious clarification of the future in the light of the long evolutionary past and of the study of human potentialities. Once this has been done, greater realization of possibilities rather than higher productivity, fulfilment rather than efficiency will become the over-riding aim."

The chapters on psychology, psychoanalysis and anthropology contain historical accounts of their subjects from the practical point of view, and show their significance in relation to modern needs.

Of particular interest is Dr. Bronowski's last chapter of fifty pages on "Science as Foresight". "Machines, like animals, have evolved in two directions: the one toward muscle and strength, and the other toward brain and foresight. We can use knowledge to help us control our relations to our environment because it gives us foresight. That is, experience encourages us to believe that the future follows the past in a repeatable pattern; and knowledge helps us to isolate and to forecast this pattern." Thus, Dr. Bronowski deals with the new electronic calculators and follows with a simple description of those which have a mechanism for adaptation and learning. Such machines, which change not only their answers but also their approach to a problem as a result of their own findings, form an interesting analogue to the human brain. Dr. Bronowski deals in a lucid manner, by using analogues and diagrams, with the circuits of electronic calculating machines, binary notation and the programming of machines. From here he touches on topics in the fields of cybernetics, the exploring machine, game-playing machines, information theory, information and entropy. The last part of the chapter is devoted to the logic of science and the nature of scientific knowledge. He anticipates the development of a machine which will have a more subtle, human characteristic—that of being able to base foresight on insight. "The processes of nature can be pictured as messages written in a code whose unit-symbols are unknown to us. All that we can do, at any state of our factual knowledge, is to prefer that code which makes what we know most orderly. That is, we choose those concepts which organize the messages of nature most coherently, by maximizing their content of information or meaning. This is the test for the inductions by which we try to generalize from our particular experience and to gain a basis for foresight."

There is an up-to-date bibliography with notes on each book, given under the headings of the chapters.

W. L. Sumner

VIRTUOUS QUARRELS

Custom and Conflict in Africa

By Prof. Max Gluckman. Pp. ix+173. (Oxford: Basil Blackwell, 1955.) 12*s*. 6*d*.

THIS book contains the text of six lectures by Prof. Max Gluckman that were broadcast by the B.B.C. during the spring of 1955. Each lecture is concerned with one of the standard topics habitually discussed by academic social anthropologists, namely, feud, chieftainship, family structure, witchcraft, ritual and race relations. The presentation is admirably clear. As a handbook for undergraduate anthropologists alarmed at the prospect of approaching examinations, it can be heartily recommended.

For the more sophisticated the interest of the book is of a different kind. All six lectures are hooked to a common theme which, in parody, might be represented thus: (*a*) people who quarrel are people who have common interests; (*b*) people who live together as members of the same political corporation have many common interests; (*c*) therefore, people who live together as members of the same political corporation will have many quarrels. Thus stated, the syllogism is no more than a logically fallacious platitude, and yet it is essentially the same as the Durkheimian thesis that groups which express social solidarity at one level of opposition will be internally segmented by faction at another. Prof. Gluckman has given the argument a novel twist by turning the third leg of the syllogism back to front so as to read (*c*) therefore, people will have many quarrels in order that they may live together as members of the same political corporation.

Thus garbled, the argument might seem even sillier than before, and yet in Prof. Gluckman's hands it becomes a most illuminating paradox. He shows,

for example, that the conventions which governed the operation of the Anglo-Saxon vengeance group were rules which must lead to peace rather than anarchic war. Similarly, he demonstrates that in many different African societies there is a wide range of situations in which the hatred generated by structures of authority is quite explicit. Rebellion against legitimate office-holders is almost institutionalized. Paradoxical perhaps, and yet clearly the public expression of hatred is also a public assertion of the high value of that which is hated. The Barotse, we are told, "state explicitly that it is the lot of leaders to be hated, because they are the Law itself".

With regard to the family, Prof. Gluckman argues that, where relationship is effectively maintained among a wide circle of kinsmen, then husband and wife must of necessity be somewhat estranged. Even malice is claimed to have a positive value; witchcraft accusations, by projecting the responsibility for evil on to the scapegoat witch, permit the ordinary man to retain his faith in the moral virtue of brotherly love even when his own daily actions are anything but kindly.

In all these cases there is the common theme that it is an essential feature of the working of any social system that the 'friends' of one context should be the 'enemies' of another. It is the divided loyalties of the individual resulting from this contradiction which makes peaceful co-operation humanly possible. This, it is maintained, is true even in the context of the colour bar of South African native reserves. It is all very ingenious; such an analysis has many applications much nearer home than South Africa. A useful and well-selected reading list has been added to the text of the original spoken lectures.

E. R. Leach

DICTIONARY OF TELEVISION AND RADAR TERMS

Elsevier's Dictionary of Television, Radar and Antennas in Six Languages

English/American; French; Spanish; Italian; Dutch and German. Compiled and arranged on an English Alphabetical Base by W. E. Clason. Pp. viii+760. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1955.) 120*s*.

THIS is a most welcome addition to the reference books dealing with the recent applications of radio to radar and television techniques. Most workers in these fields find that, sooner or later, they have to discuss progress with their contemporaries in other countries or to read accounts of scientific and technical progress in other languages. The advances made during the past decade have been so revolutionary that most existing technical dictionaries are in many respects obsolete. Moreover, as science becomes more and more international, there is a growing need for multilingual dictionaries. It was with the view of meeting this need that the publishers planned a series of polyglot technical dictionaries, of which this one is the first, dealing with television and radar and the aerials used with both these applications. In planning this dictionary, the author and publisher have been guided by certain principles proposed by Unesco. The object of these principles is to ensure that each dictionary produced according to them shall fit into place in a pattern which, it is hoped, may progressively extend over all inter-related fields of science and technology and cover all necessary languages.

The arrangement and lay-out of this volume have clearly been the subject of much serious thought and experiment. At each double-page opening the reader is presented with, on one side, the English term or phrase in bold-face type, and a brief but adequate definition of this term; while on the other page are given the equivalent terms in each of five other languages—French, Spanish, Italian, Dutch and German—the gender of the term being indicated in each case. Each definition is numbered at the extreme left and right, respectively, of the double page. The basic language being English/American (according to the publishers), these definitions are arranged in alphabetical order. But the book is completed by five alphabetical indexes for the other languages mentioned, giving the numerical reference to the English term. Where the usage of the 'English' term differs in Britain and in the United States, this is made quite clear, and the appropriate cross-indexing is included. It is interesting to note that a number of the terms are followed by the italic letters *sl*, meaning slang or code-names, which are or have been in common use among those engaged in the development and application of radar in Great Britain and the United States. Some, but not all, of these have been found to have equivalent terms in other languages.

The bibliography appended to the volume shows that full use has been made of the glossaries and technical dictionaries published in various countries, including those of the British Standards Institution, the American Standards Association and the International Civil Aviation Organization.

The publication of this work is very opportune at the present time in view of the growing importance of the exploitation of radio aids to aerial and marine navigation, and the need to facilitate the international exchange of programmes in the further advance of television. The production of the book is excellent; it is of a handy size, in a semi-flexible binding, and provided with a convenient thumb-index to the different languages. It should be readily available for immediate reference by every scientist and engineer engaged in the fields of television, radar and the associated antenna systems.

R. L. Smith-Rose

SPECTROSCOPY AT CENTIMETRE WAVE-LENGTHS

Microwave Spectroscopy

By Prof. C. H. Townes and A. L. Schawlow. (International Series in Pure and Applied Physics.) Pp. xviii+698. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 90*s*. 6*d*.

Spectroscopy at Radio and Microwave Frequencies

By Dr. D. J. E. Ingram. Pp. xii+332. (London: Butterworths Scientific Publications, 1955.) 45*s*.

MICROWAVE spectroscopy may in some respects be regarded simply as an extension of both radio-frequency measurements and of infra-red spectroscopy to the spectral region lying between 3×10^9 c./s. and 3×10^{11} c./s. (that is, to wave-lengths between 10 cm. and 1 mm.). The techniques of measurement may be derived from each of these

limits or be entirely characteristic of the centimetre wave-length range itself. Thus the bolometer is more usually recognized as a detector for infra-red radiation, whereas the barrier layer rectifier is a circuit element often used at radio frequencies. Both of these may be used for micro-wave measurements; but in addition there are the reflexion klystron and magnetron as sources of power, the waveguides and cavity resonators as transmission networks which are features peculiar to the microwave techniques and warrant a separate discussion.

The results obtained from the microwave measurements also have some similarity to those derived from the radio-frequency and infra-red regions of the spectrum, but yet have additional and important contributions to present. Gaseous spectra in the infra-red are usually concerned with transitions between the molecular vibrational energy-states, and the rotational motion gives rise to a fine structure while nuclear effects are rarely resolved. In the centimetre region, however, the absorption spectra arise directly from rotational transitions, and a structure from the electric quadrupole moment of the nucleus is readily observed. The Stark effect also now gives rise to large perturbations of the energy-states and provides not only a useful method for detecting the spectra and identifying the transitions, but also enables the molecular electric dipole moment to be determined accurately. The Zeeman effect is less frequently used for the investigation of gaseous spectra, since few molecules are paramagnetic in the ground-state; but the extension of microwave spectroscopy to the absorption spectra from the solid state has been confined almost entirely to the investigation of transitions between the ground-state energy-levels of paramagnetic sites in crystal lattices. These measurements have provided detailed information about the ground-state wave functions of transition-group ions, they have allowed the determination of a number of nuclear spins, and they are powerful techniques for the investigation of the different types of chemical bonding and the structure of lattice defects.

The first measurements at centimetre wave-lengths were carried out in 1934 by Cleeton and Williams; but there was little subsequent work in this field of research until 1946, by which time the development of radar had provided sufficient instruments and experienced operators. During the past ten years, however, there has been such enormous activity that a review of the principles, the techniques and the results is now both desirable and necessary. To discuss adequately the whole field of microwave spectroscopy would be a formidable task, and the title of the book by Prof. C. H. Townes and Dr. A. L. Schawlow disguises the fact that these authors have very wisely limited themselves to a considered treatment of the microwave measurements on gases. It is a well-written book which treats the subject-matter with authority and maintains the reader's interest. The early chapters give a thorough discussion of the theory of microwave molecular spectra, while the later sections are concerned with the various microwave spectroscopes and contain a great deal of useful information about the measuring techniques. There is also an extensive bibliography with about a thousand references.

The book by Dr. D. J. E. Ingram is of quite a different type. The author has endeavoured not only to cover the whole field of microwave spectroscopy in all its aspects but also to include the radio-frequency measurements on molecular beams and nuclear resonance. The treatment of individual topics is therefore necessarily very brief, and the reader may soon lose interest. One is left with the impression that too much has been concentrated within the compass of one volume, an impression which is furthered both by the print and the diagrams, which also seem to be compressed. However, Dr. Ingram's book does include a great deal of information, and the reader seeking a more detailed discussion of any particular topic will find a carefully presented series of references. It is a book, therefore, which is a survey rather than an authoritative text and may be found useful by many of those who are wondering whether and how to start out into the field of microwave spectroscopy.

D. M. S. Bagguley

POLYNESIAN TALES IN POETRY

Voices on the Wind

Polynesian Myths and Chants. By Katharine Luomala. Pp. iv+191. (Honolulu: Bernice P. Bishop Museum, 1955.) n.p.

ALL peoples have their folk-lore and fairy tales, often transmitted in the form of poetry. Their study is of great importance since past events as well as the outlook on life of the people themselves become enshrined in the tales. The story of Jason and the Golden Fleece probably results from an actual prospecting expedition to the head of the Black Sea. We can be very grateful, then, to Katharine Luomala for this volume, which recites a number of Polynesian tales. A Maori mother tells her mischievous son that he is a "Maui-of-a-thousand-tricks". The lad is flattered, since what boy in the South Pacific can ever hope to match a single prank of the demi-god, the hero of innumerable adventures. But who was 'Maui'?

The Fakahina Island (formerly Niuhi) folk live on an atoll around which blow violent winds tending to force canoes out to sea. Here is a poem about it by some unknown Fakahina composer:

> This is Niuhi, land of gales.
> Sail the canoe outside—it is driven to sea.
> Sail the canoe inside—it is driven to sea.
> Mark, will you, the form of the land of Niuhi,
> Like a roll of Hala leaves,
> When sinks,
> When wanes,
> The Northeast wind.
> (Fails my breath!)
> O speed the fame of Niuhi
> to the world!

The account of the occupation of New Zealand is too long to quote here, but is equally fascinating. Naturally, some of the tales owe their origin to outside influences—often impossible nowadays to trace. Thus the story of the hero who builds a great boat just before a vast flood must have been introduced into the folklore. Few people have grown up in entire isolation; somehow or other, ideas developed in one area found their way around the world even in ancient times. But it is only when we have studies like those under review that we can obtain a picture of the ideas of a people and sometimes hints of past events in their history. The poems are charmingly rendered into English and the black-and-white illustrations are delightful.

M. C. Burkitt

Electricity : Direct and Alternating Current

By Prof. Charles S. Siskind. Second edition. Pp. xii+538. (London : McGraw-Hill Publishing Company, Ltd., 1955.) 43*s*.

THIS is an elementary text-book. As the author states in his preface, it "is intended for use in technical institutes, junior colleges, and short courses for non-electrical engineering students in universities . . ."

The first four chapters deal with direct current. Chapter 1 is concerned with basic ideas of conduction and the effects of electric current ; the second and third chapters deal with resistance calculations for conductors, and d.c. circuits, respectively ; the following chapter discusses basic theorems and laws, for example, those of Kirchhoff, and the superposition and maximum power transfer theorems. These are illustrated in terms of direct current ; but there is no mention of their application to the a.c. circuits, which appear in Chapter 5. As magnetism and electromagnetism are deferred until Chapter 6, this means that inductance is introduced before electromagnetism is touched upon. Then, unlike most British text-books, the chapter on electromagnetism has no mention of inductance. The remaining four chapters deal with d.c. measuring instruments, electromagnetic induction, generators, and motors.

The book on the whole is written quite clearly and is excellently produced. It would be suitable for National Certificate students. The advantage, however, of having such an American book (good of its kind as it is) in Britain does seem doubtful. The case against it is that it is expensive, there are British text-books available which cover the same material, and, of more consequence, the illustrations of usage and the units are those employed in American practice. As an example, flux density is quoted in kilolines per square inch, a quantity not commonly employed in British teaching. W. FRASER

Chemistry of Carbon Compounds

A Modern Comprehensive Treatise. Edited by Dr. E. H. Rodd. Vol. 3, Part A : Aromatic Compounds. Pp. xxiv+685. (Amsterdam : Elsevier Publishing Company ; London : Cleaver-Hume Press, Ltd., 1954.) 115*s*.

WITH the appearance of the first part of the third volume, this well-known compendium reaches that solid bed-rock of organic chemistry—the aromatic compounds. Although this is, of course, a well-trodden subject, recent work—for example, on 'benzyne' and the non-benzenoid aromatic compounds—shows that the field is by no means spent.

The volume begins with a series of articles by authorities which seek to survey the familiar facts in terms of modern concepts. Prof. C. K. Ingold contributes two such essays dealing with the benzene nucleus and orientation in electrophilic aromatic substitution ; the result is an object lesson in clarity and brevity. Prof. D. H. Hey and Dr. G. H. Williams perform the same function for nucleophilic and homolytic substitution, and Dr. N. Campbell ends this preliminary survey with a discussion of the formation and fission of the benzene nucleus.

The rest of the volume is devoted to a factual survey of the benzene series and simple derivatives thereof. This considerable task has been largely handled by Dr. W. J. Hickinbottom, with smaller contributions from Drs. J. Chatt and Z. E. Jolles. The presentation follows the pattern laid down in the previous volumes, although the enormous amount of material available has needed more drastic selection. More complex mononuclear derivatives and polycyclic and pseudo-aromatic structures are to be dealt with in Vol. 3, Part *B*. R. A. RAPHAEL

Organic Chemistry

By Dr. I. L. Finar. Second edition. Pp. xv+732. (London : Longmans, Green and Co., Ltd., 1954.) 40*s*. net.

THIS text, which is suitable for students reading for a university honours degree, was first published in 1951. It rapidly became popular, and a new edition was soon required. This popularity was possibly largely due to the author's plan of not adding the electronic theory as a tail-piece, but blending it in with the descriptive material, a plan which helps the student to make classifications and see inter-relationships and one that is conducive to an understanding of the subject. Conforming to the international rules of nomenclature, adopted in Britain by the Chemical Society in 1950, Dr. I. L. Finar has now written prefixes denoting substituents in alphabetical order. The new system was announced too late for inclusion in the first edition.

Among the other changes are enlarged sections on molecular orbitals, reaction mechanisms, stereochemistry, heterocyclic compounds and dye-stuffs. Thus the introductory section on molecular orbitals now occupies six pages. Dr. Finar, dispensing with mathematics, offers a simplified explanation of the concept and expounds its significance for the understanding of bonding problems. Thereafter, for instructional purposes, he uses it in conjunction with the valency-bond theory. These additions undoubtedly improve what was already a good book.

G. F.

The Moon

A Complete Description of the Surface of the Moon, containing the 300-inch Wilkins Lunar Map. By Dr. H. Percy Wilkins and Patrick Moore. Pp. 388+14 plates. (London : Faber and Faber, Ltd., 1955.) 63*s*. net.

THIS discussion of the physical features of the Moon's surface includes a chart in twenty-five sections on a scale of 32 inches to the Moon's diameter. It is reduced from the larger one by Dr. H. P. Wilkins published in 1952. Each section is accompanied by a description of the principal formations represented therein, the rectangular co-ordinates, elevations, and dimensions being given in most cases. The chart is based on visual and photographic observations, and the surface is shown in great detail. A number of large-scale drawings and reproductions of some excellent photographs supplement the chart. Considerable attention is given in special maps to features near the limb, which are difficult to study even under favourable conditions of libration and illumination.

The introduction summarizes the history of selenography and reviews the classification of the various types of formations. Several pages are devoted to an examination of suspected changes in the lunar surface that have been reported from time to time. A useful account of the techniques employed in lunar photography is given in an appendix by E. A. Whitaker.

The volume will provide for beginners an attractive introduction to the study of the Moon's surface ; for practised workers in the field it will serve as a useful supplement to earlier publications.

PEACEFUL USES OF ATOMIC ENERGY

By Dr. T. E. ALLIBONE, F.R.S.

THE papers submitted to the Geneva Conference last August were prepared at great speed, printed in many cases by offset lithography, and were illustrated with diagrams of indifferent quality. The United Nations is now publishing the full proceedings in a series of sixteen volumes in which the papers are grouped into main subjects, together with the discussion at the end of each session of the Conference. Vol. 3, on "Power Reactors", was the first to appear, followed by Vol. 2 on "Research Reactors" and Vol. 14 on "Isotopes"*. The volumes are printed on a high-quality paper on which all diagrams and photographs appear with excellent definition, and editing has been of such a high standard that in the detailed reading and study of a dozen of the papers I have failed to find a mistake. The discussion is recorded verbatim—which I think is a pity. In Britain we accept severe pruning of the printed record of a discussion in the interests of brevity; the recorded discussion in these columns could have been cut by 75 per cent without any loss of scientific context. However, the time allowed at Geneva for discussion was so short that it was the least important feature of the Conference.

Vol. 3, "Power Reactors", is for the engineer and applied physicist possibly the most interesting and important of all the proceedings. Here we have American, Russian and British accounts of the post-war design and construction of power reactors, and to many attending the Conference these accounts contained much that was new. There are also important authoritative plans for the future particularly emanating from the United States, while ideas from Holland contain great originality. To those who ask which country is ahead in reactor development, the answer can be given that all three of the Great Powers have 'firsts' to their credit: the American breeder reactor first produced 100 kW. of electrical power in 1951, and the submarine reactor produced an undisclosed amount of power in 1953; the Russian graphite water-cooled enriched reactor first produced 5,000 kW. of power in 1954; while the British 'first' will be the first 50,000 kW. generation of power from a natural uranium gas-cooled reactor—possibly this summer. In magnitude of effort based on population, Britain and America are almost on a par: Great Britain has two major developments, the gas-cooled natural uranium reactor and the plutonium breeder reactor, whereas America has her famous five-point programme of designs now being built. The U.S.S.R., on the other hand, would appear to be behind—at least plans were only referred to in very general terms, from which it is not possible to infer how many different types have been seriously pressed. In spite of the taunts often flung at the United States for its over-developed sense of security, the American papers disclose far more detail than the British or Russian papers, and in the Exhibition at Geneva there were beautiful examples of American fuel elements of all kinds.

As Dr. A. M. Weinberg stated in an opening review, there are a large number of types of reactor, of which a dozen or so are very promising; and the central issue is to trace out of this welter those most likely to succeed. Again, it depends on what is meant by 'succeed'. Great Britain, with a limited gaseous diffusion plant, has chosen to concentrate on the design which uses natural uranium, whereas the U.S.S.R. prefers to build a 100,000-kW. station using a reactor enriched to 2·5 per cent; and when Academician Kurchatov was in Britain recently he stated that it is more economic to use enriched fuel in a water-cooled reactor than to use natural uranium in a gas-cooled reactor. The United States five-point plan of reactors uses enriched fuel in all designs. The answer will not be found until the reactors have been built and operated for some years, during which time industry will be developing better designs of the existing types.

The American industrial reactor most advanced in construction is the pressurized water reactor (*P.W.R.*) being built by Westinghouse at Shippingport to supply 60,000 kW. of power to the Duquesne Light Co. and due to operate next year. Light water at 2,000 lb. per sq. in. is both the moderator and the coolant flowing through the reactor at 200 tons a minute and being raised only 34 deg. F. The pressure is kept high to prevent boiling, since boiling and steam formation result in instability of power output, localized hot-spots, and in pitting of the reactor vessel. (It is noted that in another American design boiling is freely allowed, and discussion did not clear up this paradox.) The reactor vessel is of formidable proportions, 33 ft. in height, 9 ft. in internal diameter and 8½-in. wall thickness with a removable closure head. The core is small, only 6 ft. in diameter and height; it contains 12 tons of uranium in the form of oxide with an additional enrichment of ½ per cent of uranium-235 localized in 'seeds' in the core, and will have a breeding coefficient of 0·8, that is, produce eight atoms of plutonium for ten atoms of uranium-235 undergoing fission. The design appears to be conservative and safe: the manufacture of pressure vessels is reliable, absence of boiling avoids many uncertainties, the temperature is moderate—only 540° F.—and the materials are well known; the only 'exotic' material is hafnium, used as a control rod. What is not easy is the detection and removal of burst fuel elements.

By contrast, the Argonne Laboratory has experimented widely with a water-cooled, water-moderated reactor operating at only a few hundred lb. per sq. in., so that boiling occurs low down in the core as the water is pumped upwards, and such a reactor to develop 5,000 kW. of electricity is now under construction. The daring experiments conducted on the first experimental reactor have shown how inherently safe is this design when steam voids are formed in the core, and when pressures are suddenly lowered or raised; no other reactor has been treated in this same free-and-easy fashion. Protagonists of this design also place weight on the lower temperature

* Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, held in Geneva, 8 August–20 August, 1955. Vol. 2: Physics: Research Reactors. Pp. viii+471. 8 dollars; 57*s.*; 34 Swiss francs. Vol. 3: Power Reactors. Pp. viii+389. 7.50 dollars; 54*s.*; 32 Swiss francs. Vol. 14: General Aspects of the Use of Radioactive Isotopes; Dosimetry. Pp. viii+305. 6.50 dollars; 45*s.*; 28 Swiss francs. (New York: United Nations; London: H.M. Stationery Office, 1955 and 1956.)

of the fuel elements, with consequent less corrosion damage; but as there is such a big difference in power output of the pressurized and boiling-water reactors, the cost comparison given in the summarizing paper in this volume is not significant.

The American sodium-cooled graphite-moderated reactor is one of the most daring designs, and is due to operate this year at a heat output of 20,000 kW. (not to be connected to an electrical generating plant). The attraction is the avoidance of high pressures, the ability to reach high temperatures (1,000–1,200° F. are mentioned in two papers, one of which is speculative) and the ease—because of absence of a pressure vessel—of replacing fuel elements. The penalty is the necessity to encase the graphite moderator blocks in thin-sheet zirconium cans, and to conquer the problems of sodium or sodium–potassium cooling; these had to be resolved for the fast-fission reactors and appear to be spoken of with great confidence. North American Aviation Co. has a plan for a 75,000-kW. generating station based on the present work, and anticipated costs are low.

One cannot, however, escape from the feeling that there is a tremendous waste of metallurgical effort in reactors so far described. All this advanced metallurgy has to be undertaken so long as the fuel is used in solid form; does the homogeneous reactor or the liquid-metal fuel reactor point the way to the future? The former is on the five-point programme, the latter has not yet got so far. The former has a long history dating back to the Los Alamos 1944 water-boiler; now it looks forward to producing 10,000 kW. of heat this year using highly enriched uranyl sulphate solution in heavy water, with a blanket of thorium solution in which the breeding coefficient may exceed unity. The design calls for very high pressures—2,000 lb. per sq. in.—to prevent ebullition; but the vessel for this power rating is only 5 ft. in diameter, including the blanket. Another attraction is the inherently high stability due to the negative temperature coefficient of reactivity; but there are serious hazards, the greatest of which is leakage, since the whole vessel and all the pipes to heat interchangers, etc., contain solutions carrying fission products. This reactor does not appear to have the support of industry; it is the work of the Oakridge Laboratory of the United States Atomic Energy Commission.

American industry has become much interested in the fast breeder reactor based to a large extent on the Argonne reactor now under construction for 60,000 kW. of heat. In this, liquid sodium flows at 11,000 gal./min. past stainless steel tubes containing in the core a plutonium–uranium alloy, and in the blanket uranium-238. In spite of the very high specific thermal loading, the reactor is regarded as safe, partly due to the large volume of sodium in the primary system which provides thermal inertia, and great hopes are centred on this engineering development: it holds out the ultimate goal of breeding all the fuel needed for future reactors; indeed, breeding *must* be successful for the long-term success of nuclear power.

The British reactor plans have received wide publicity, but the amount of detail supplied about the Dounreay reactor is far smaller than that for the Argonne reactor; so the reader of these volumes of the Geneva Conference is not able to judge whether the problems are being tackled on very different lines. The note of caution was struck more in the Dounreay description, and for safety the reactor is to be housed in a steel sphere, as is the American *G.E.* reactor; but the Argonne reactor is not so encased.

Vol. 2, "Physics: Research Reactors", supplies the basic information on which the power reactors have been developed, and describes the many forms of research reactors with which reactor experimentation has been and will continue to be done, including the testing of fuel elements in high neutron fluxes.

One-half of Vol. 14 is concerned with the preparation and use of radioactive isotopes in industry in many countries, the other half contains thirty papers on dosimetry. As Dr. P. C. Aebersold says in his opening review paper, "The Importance of Isotopes in Industry", the uses of isotopes have grown rapidly in nine years, but they are still far from attaining their world-wide potential for the gaining of new knowledge. The papers in this volume should be widely read by scientists in industry and in research associations, so that in appreciating what has been done readers may the more vividly appreciate what steps they can take in their own organizations. The diversity of uses is too great to review in a short paragraph; each country has some new examples to quote, but Mr. S. E. Eaton's American paper shows how a company specializing in tracer techniques can range far and wide in suggesting solutions to countless industrial problems of considerable complexity.

With the advent of kilocurie gamma-ray sources, the X-ray supply industry is affected. There is a big jump in the number of firms now using radiography for inspection and fault detection. We are about to enter a new phase of development, when megacuries of cæsium per annum become available from the power reactor processing plants, and when spent fuel elements may be employed to give doses of megaröntgens per minute. With sources of these magnitudes, the chemical, agricultural and the food industries may begin to benefit on a really large scale in a few years time.

ECOLOGY OF *ANOPHELES GAMBIAE* GILES

By JAMES G. HALCROW

DURING the past three years, a small research unit of the Colonial Insecticides, Fungicides and Herbicides Committee has been engaged in an ecological study of *Anopheles gambiae* Giles in Mauritius. This insect has survived and increased; yet as a result of an intensive house-spraying campaign, the incidence of malaria on the island has been reduced to very small proportions. It was considered desirable that the matter should be investigated.

Many workers in Africa have commented upon the ease with which this anopheline can transmit malaria; yet at no time has a *prima facie* case been made out against it as a vector of malaria in Mauritius. It has always been condemned on African, rather than local, evidence; though a worker in Mauritius,

some thirty years ago, declared it was not "a domestic mosquito". The large-scale malaria eradication scheme of 1948–52 for Mauritius, based on residual insecticidal house-spraying, was, unfortunately, not fully documented on its entomological aspects; but it did eradicate *Anopheles funestus* Giles, while failing to control *A. gambiae*. Malaria is almost unknown in the island, at the time of writing. The problem in 1952 was then a virtual absence of proved malaria in the abundant presence of a potentially powerful vector. Possible theories at that time were based on 'zoophilic' or 'DDT resistant' vectors. I have not obtained confirmation of them at any time; I found *A. gambiae* to be a facultative feeder and to be generally highly susceptible to effective DDT contact.

The host preferences of *A. gambiae* were in 1952 quite unknown, though the high percentage with thoracic, and proboscal, infections of *Filaria bancrofti* argued against a purely zoophilic feeding regime. Stomach smears of 1,254 insects in all were examined at the Lister Institute, London; most of them showed blood of bovine origin, but a majority of the insects were found in and around cowsheds. The majority of them preferred to rest in cowsheds, typical counts averaging 20–200 *gambiae* per cowshed. In houses examined, on the other hand, the average was less than one per hundred houses. It is further of interest that malaria and bancroftian filariasis are sometimes confined to the inhabitants of a small group of houses in a village. This 'parochialism' of *gambiae* may be due to the fact that it is not generally an insect of strong and sustained flight, so that little migration from an attractive feeding and resting site takes place. Captive female *A. gambiae* seem better able to mature their ovaries on a diet of human blood (see Table 1).

Table 1. Percentage of female *A. gambiae* maturing ovaries after a single feed of blood

Man	78
Cow	62
Deer	49

In Mauritius, there is a wild-animal reservoir estimated at about ten thousand deer, plus many monkeys and some wild pig. In the sister island of Réunion, the wild animals are absent, and the people may therefore lack a valuable protective barrier against *A. gambiae*.

Figures were obtained which show that the nocturnal population of *A. gambiae* in cowsheds was largely composed of unfed mosquitoes. The day population of females was principally in the late blood-fed or half-gravid stages. Ovarian dissection of both day and night populations showed a ratio of nulliparous to parous insects of approximately 9 : 1. Gravid females were commoner in cowsheds by day than by night; this suggests an early evening exodus.

By experiment in the insectary, the gonotrophic cycles (the time-interval between partaking of the initial blood meal and the commencement of egg-laying) were studied in the winter and summer seasons. The abdominal/ovarian classification used was that put forward by many authors, namely:

Stage 1.	Unfed:	thin, non-distended abdomen.
Stage 2.	Blood-fed:	abdomen gorged with fresh red blood.
Stage 3.	Half-gravid:	black mass of blood in abdomen; apex of abdomen becoming yellow-white in colour.
Stage 4.	Gravid:	blood digested, abdomen distended with eggs.

The gonotrophic cycle in winter extended over 97 hr.; that in summer took 94 hr. to complete. There did appear to be a tendency for the gonotrophic cycle to shorten or lengthen according to the host animal in use.

Activity cycles of *A. gambiae* were studied throughout the night on numerous occasions. (The nocturnal study of a nocturnal insect is still so rare as to be worthy of note.) It was found that the Mauritian *gambiae* reached its peak of activity earlier in the night than did the *gambiae* of Africa. At first, it was not clear whether this might be due to some genetical difference, for an introduction of the mosquito into Mauritius would not, unless it were a massed or repeated introduction, carry the full genetical potentialities of the species. However, other Mauritian mosquitoes, for example, *Anopheles constani* Lav., and *Culex fatigans* Wd., show this same early peak of nocturnal activity. From other islands also there have come reports of *gambiae* activity reaching a late crepuscular peak. It is possible that the rapidly rising relative humidity of the night air, in a small island, may cause the cessation of flight activity.

After field-studies, the nocturnal activity of *gambiae* was considered in the insectary, where 'biting cycles' were studied. The 'biting cycle' was defined as the hour-to-hour fluctuation in a nocturnal population of unfed *gambiae*, whether parous or nulliparous female, which were seeking a blood-meal. The 'activity cycle' was defined as the hour-to-hour fluctuation of a nocturnal population of *gambiae*. The latter cycle considers the population in general, the former judges the intensity of attack by the female on the host. The 'biting cycle' was found to be some 1–2 hr. later in its peak than the general activity cycle. The early nocturnal peak of activity of *gambiae* is of interest in that it coincides with the time of night when the human population are out-of-doors engaged in various and varied social activities. In effect, *A. gambiae* need never enter a house to secure a blood-meal. On the subject of houses, it is noteworthy that the walls, treated annually with DDT, are re-plastered with mud and dung every New Year and on certain other festivals. A wall sprayed with insecticide two or three days previously may then be covered with fresh plaster and remain untreated until the next spraying.

It was confirmed that *A. gambiae* in Mauritius was a minor vector of bancroftian filariasis; the major vector was found to be *Culex fatigans* Wd., a mosquito not easily deviated from man; indeed, it was noted that 84·0 per cent of the *C. fatigans* collected from cowsheds had fed, not on cattle, but on man. The status of *A. gambiae* as a vector of malaria is far from clear. Past records, when available, indicate little of value. Of 4,526 dissections of stomachs and salivary glands since 1952, only two light stomach infections were observed. In the continued and abundant presence of *A. gambiae* and the present low level of diagnosed and proved cases of malaria, it would seem reasonable to regard *A. gambiae* as a poor vector of malaria in Mauritius. It is not, perhaps, remarkable that despite DDT and anti-malarial drugs, malarial cases still occur from time to time; what is remarkable is that in spite of adulticides, larvicides, drainage works, and health education, *gambiae* has not only survived but has even increased its range. Its ability to recover from natural catastrophes was seen in 1955, when torrential rains and high winds caused by a close approach of a cyclone destroyed the immature stages. Within days, more immature stages began to appear, presum-

ably from eggs laid by the gravid females which sheltered indoors and had escaped destruction.

The rapid completion of the life-cycle during the summer months—about seven days from eclosion to adult emergence—undoubtedly helps the insects to make good any losses suffered. The winter life-cycle occupies about fifteen days from eclosion to adult emergence. Various authors have commented that, in Mauritius, the extinct *A. funestus* had a life-cycle at least three times as long as that of *A. gambiae*. It is possible that *A. funestus* was unable to build up its numbers when attacked by residual insecticides because its life-cycle is too long.

The ecology of the egg of *A. gambiae* was confined to eclosion studies, size of egg batches, and resistance shown by the eggs to salinity and desiccation. The duration of the egg stage in waters of known composition was found to be significantly longer in winter than in summer. Egg batches per female were larger in summer, both for the eggs of later gonotrophic cycles as well as for the first cycle. The numbers of eggs per batch fluctuated according to the host animal in use (Table 2).

Table 2

Host animal	Eggs per female *A. gambiae*
Man	140 ± 5·4
Deer	123 ± 8·9
Cow	111 ± 9·4
Guinea pig	105 ± 8·9
Rabbit	100 ± 9·6

Eclosion took place to some extent in water heavily charged with sodium chloride or copper sulphate. Continued development of the emerging larvæ was found to cease when the sodium chloride content rose to 17·5 gm. per litre. Eggs kept on damp filter-paper at room temperatures gave good eclosion-rates after 10–14 days. Normal eclosion was considered to be 78 per cent or more. Eggs placed on dry filter-paper at room temperatures failed to hatch after six days.

Standing agricultural water was found to form at least 43 per cent of all breeding sites. The sites of standing water in cane fields were ever changing; rarely did a site allow for the emergence of more than two generations. As one site drained away, or evaporated, another might appear as little as twelve inches away.

The period when the pupation-rate reached its maximum was studied by observing personally the pupation of 9,785 fourth instar larvæ (see Table 3):

Table 3

Time	Pupation (per cent)
Daylight hours (6.0 a.m.–5.0 p.m.)	12
Twilight ,, (5.0 p.m.–7.0 p.m.)	56
Night ,, (7.0 p.m.–6.0 a.m.)	32

Some little work was done on the parasites and predators of the larvæ of *A. gambiae*. Protozoan and fungal diseases were observed; but few results of any practical value were gathered concerning the predators.

Brief morphological studies were made; for example, (*a*) a study of the tarsal sensillæ, and (*b*) the maxillary index. Of (*a*) little resulted; clear-cut differences of taxonomic value were not to be found between individuals of the main population and individuals of the salt-water group. A comparative study of the maxillary dentitional range of *A. gambiae* and four other Mauritian mosquitoes has been made. The maxillary dentitional range of the Mauritian *A. gambiae* was determined to be twelve to sixteen teeth.

A subsidiary study was carried out on the saline-loving group of *A. gambiae*; known loosely (and wrongly) in Mauritius as either '*A. melas*' or 'salt-water *gambiae*'. In a paper to be published elsewhere, morphological and biological observations will be presented to support the erection of this group to formal sub-specific rank.

The full report on which this brief account is based has been deposited with the Colonial Products Laboratory, Imperial Institute Buildings, London, S.W.7.

THE ABYSSAL FAUNA: ITS ECOLOGY, DISTRIBUTION AND ORIGIN*

By Dr. ANTON FR. BRUUN
The *Galathea* Expedition, 1950–52, Copenhagen

Ecology

BEFORE defining the environment of the abyssal fauna, its relations to the other ecological zones of the deep sea must first be outlined. This is done schematically in Fig. 1, showing the percentage partition in area of the deep-sea floor, with respect to the intervals of depth against the profile. Light and temperature conditions as they apply to tropical and subtropical regions are also indicated.

Fig. 1 shows clearly the small volume of the water masses above the thermocline, centred at about 10° C., in comparison with the cold-water masses below the 10° C. isotherm. The comparison becomes even more striking when it is remembered that on the poleward side of the subtropical areas such cold water is found from the surface to the bottom. But even the water layers of 4–10° C. and the area of the bottom they occupy are relatively small in comparison with the huge body of water with temperatures always below 4° C. and covering the greater part of the deep-sea floor at depths of 2,000 m. or more. These are the true abyssal depths, the typical habitat of the abyssal fauna.

We must here disregard such highly interesting Seas as the Mediterranean, the Sulu and the North Polar, which have no connexion with the oceans at 2,000 m. and have therefore very different temperature conditions in their abyssal reaches. Also, their total area is very limited compared with that of the oceans.

Area. The total area of the oceans and seas adjacent to them is 361×10^6 sq. km. If the upper limit of the abyssal depths is set at about 2,000 m., their area is about 84 per cent of the total area. Even if the depths between 2,000 m. and

* Substance of three University of London lectures delivered at Birkbeck College on March 5, 7 and 9.

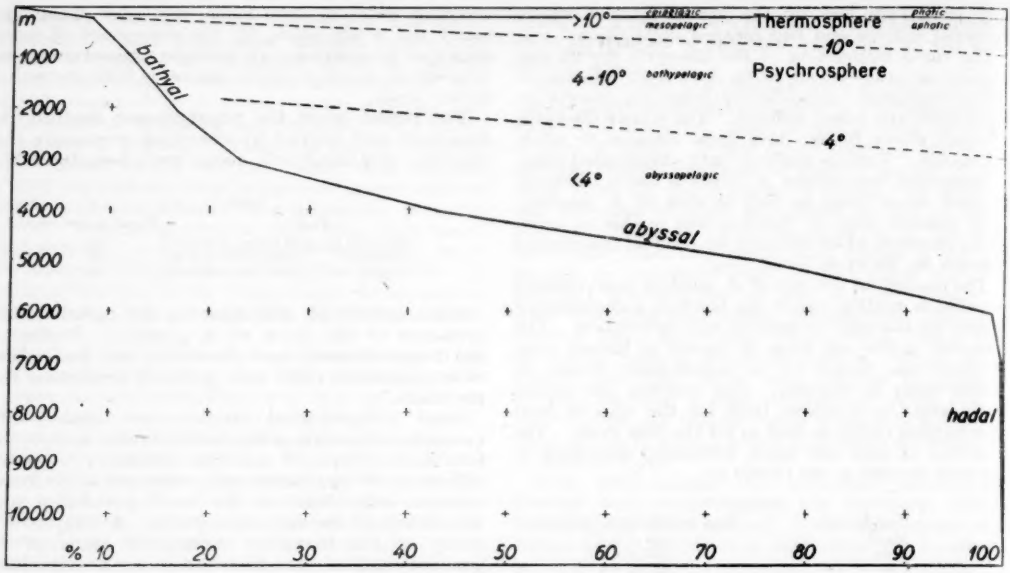

Fig. 1. Ecological zonation of the ocean

3,000 m. are excluded, the total area is only reduced by 6·8 per cent. If the extreme depths beyond 6,000 m. are excluded, there is further reduction of a mere 1·2 per cent. Therefore, by far the greater part, 273×10^6 sq. km. or three-quarters of the area, lies between 3,000 m. and 6,000 m. This is more than half the total area of the Earth (510×10^6 sq. km.). The abyss is thus the largest known ecological unit, but, unfortunately, also the least explored.

Sediments. The bottom is mostly covered by soft ooze or clay. Siliceous oozes occupy 38×10^6 sq. km., calcareous oozes 128×10^6 sq. km., and red clay 102×10^6 sq. km.

Temperatures. The abyssal zone is delimited from the bathyal zone by the temperature isotherm of about 4° C. This means that there will be a very narrow total range in abyssal temperatures, and a still narrower range within geographical areas. Furthermore, there is no seasonal variation in temperature.

Salinity. An average figure may be set at 34·8 per mille, and the variation is only about $\pm$ 0·2 per mille.

Oxygen. In general, the bottom water contains sufficient oxygen to support at least some life, as shown by the fact that large azoic areas are unknown. Koczy[1] has demonstrated a certain, sudden decrease of oxygen in the water layers from about 20 to 50 m. above the bottom down to a layer 1 m. above the bottom. In the Indian Ocean, this decrease amounts to values about 10 per cent of the oxygen content of about 4 ml./l. Brouardel and Fage[2] have shown a further decrease of oxygen in the last metre above the bottom at a depth of 460 m.

Alkalinity, pH, carbon dioxide, phosphate and silicate. Koczy has also shown a definite gradient of these chemical features close to the bottom, the alkalinity showing a slight increase, while the other constituents decrease. This phenomenon must be closely connected with biological processes; but more observations are badly needed.

Pressure. The ecological factors mentioned above are not specific for the abyssal zone in the same sense as the hydrostatic pressure, which amounts to values from about 200 to about 1,100 atmospheres. Lack of light and low temperatures may occur at shallower depths, but in combination with a high hydrostatic pressure are only found in abyssal depths. This was stressed by Fontaine[3], who carried out a series of experiments showing varying resistance to pressure in different animal groups; he also showed that the rate of metabolism of *Pleuronectes*, *Gobius* and *Palaemon* increased with pressure. Others have followed with similar experiments; but in all these only shallow-water animals have been used. It was not until ZoBell[4] succeeded in cultivating bacteria from the bottom of the Philippine Trench that the existence of organisms adapted to pressure was proved. Such barophilic bacteria must be cultivated under a hydrostatic pressure of about 1,000 atmospheres, and at a low temperature, because they are also psychrophil and very stenothermal.

It is reasonable to conclude that more highly organized animals may be still more sensitive to pressure.

Food. All organisms living below the photosynthetic zone must depend upon the amount of food existing in or sinking below this zone. The old idea of a rain of dead bodies of plankton organisms reaching the deep-sea floor has not been substantiated by finding such a settling in any quantity. But if *food* is thought of in terms of *any energy stored in organic matter*, there is certainly a rain of excrement, cast crustacean skins, tests of salps, etc., which, however, cannot be digested directly by animals. Nevertheless, 30–40 per cent of the remaining organic carbon can be converted into bacterial cell substance, the rest being oxidized by the bacteria during the process. Such bacteria may serve directly as food, with protozoans, mud-eaters or filter-feeders as the second link in a new food-chain.

It is commonly asserted that the greater the depth the less the supply of food. This is probably not so,

because the abysso–pelagic zone is so poorly populated, even with bacteria, that the amount of organic debris reaching the bottom is much the same whether the depth be 2,000 m. or 10,000 m. provided the supply from the surface is the same. Even any bacterial decomposition during the sinking must be inhibited, because of the steadily increasing pressure, and only at the bottom itself can bacterial activity really start.

It is well known that a certain number of abyssal animals live close to the surface as larval stages, such as the leptocephali of the deep-sea eel *Synaphobranchus*. When such larvæ metamorphose and start living at the bottom, they must provide a considerable amount of directly available food for the abyssal predators. Only a small fraction of the number which descend ultimately grow up for recruitment to the breeding stock.

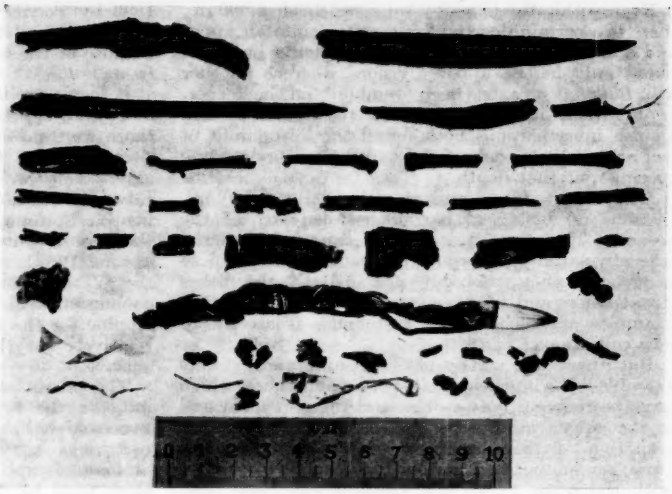

Fig. 2. Plant debris from the bottom of the Philippine Trench, 10,190 m.

Other direct sources could be the dead bodies of surface animals which are too big to be swallowed by any predator. Ear bones of whales and the teeth of sharks—the more permanent remains of these animals—are often found on the abyssal floor. A dead whale of 50 tons must attract scavengers for a long time and thus form a local focus of abundant food for predators.

There are several sources of indirectly available supplies; but their relative importance is difficult to estimate.

The amount of dissolved organic matter is probably very important. It is certainly fairly high, about 0·5 mgm./l., according to the few determinations made first by Krogh[5] and more recently by Plunkett and Rakestraw[6]. But more determinations are needed from water very close to the bottom in order to estimate the rate at which organic matter is consumed by bacteria.

Besides the particulate organic matter of animal origin already mentioned, remains of land plants, such as branches, leaves or fruits, together with seaweeds from the coastal belt, have often been included in hauls from deep water (Fig. 2). Except for a very limited amount, all this debris must be converted by bacteria into digestible matter for animals.

In many regions where plant debris has been found to be abundant, the quantity of animals has been correspondingly great.

On the whole, the food supply in the abyssal zone may not be termed plentiful; but it is no more scanty than in any other benthic zone of the deep ocean below the layers in the proximity of the photosynthetic zone.

Animal communities. It is not possible to give even an estimate of the number of species of the abyssal zone, since new species still appear in almost every haul. Furthermore, the taxonomy of several groups needs a thorough revision, which will again reduce the number of species described. It is therefore of very limited interest to state, for example, that eighty-eight species of the holothurian order Elasipoda have been found in depths exceeding 3,000 m.; or, similarly, that the ophiuroid family Ophiolepididae is represented by forty-nine species. Nevertheless, the figures must in some way indicate quite a varied fauna, and the same impression is apparent in several other major taxons.

However, the abyssal fauna can scarcely be compared with the diverse communities of a coral reef. This is not surprising, because most of the environmental conditions in the abyssal zone are so extremely uniform. The food supply and the increasing pressure with depth are the exceptions.

Ecologically, the fauna forms a typical soft-bottom community with a dominance of burrowing species, mixed with sedentary stalked species, like sponges, cœlenterates and tunicates. Exposed rock surfaces, which are relatively rare, have been even less explored than the level bottom and have revealed a poor epifauna. This is so because the quiet conditions allow sedimentation to take place on much steeper slopes than those of shallower water with its strong currents and wave action.

It appears impossible to single out any character of morphological adaptation, which is not also seen in animals from shallower ecological zones.

Distribution

Vertical. Many species have a very wide range, extending upwards even to the continental shelf; but there is no doubt that the number of species decreases steadily with increasing depth. Between 6,000 m. and 7,000 m. a considerable number of major groups disappear. This is the transition zone leading to the depths of the trenches, which at 10,000 m. in the Kurile Trench[7] and the Philippine Trench[8] contain only six and eight species, respectively. The Danish investigations in the shallower Sunda, Banda, New Britain and Kermadec Trenches gave similar results, and systematic studies have shown a large number of new species found nowhere else. Combined with ZoBell's work on barophilic bacteria, the impression is gained that the trenches form an ecological zone of their own, for which the term 'hadal' is suggested (*hades*, the Greek underworld). The all-important biological factor in the hadal zone is the high hydrostatic pressure, 600–1,100 atmospheres.

Even within the true abyssal zone, 2,000–6,000 m., there is a certain degree of segregation into an upper and a lower subzone. The fish *Acanthonus* has been found only in the upper division, whereas another fish, *Bathymicrops*, has been found only in the deeper. In addition, it may be stated that Russian and Danish investigations both found the lower limit of fish at 7,200 m., each of the expeditions finding one specimen at that depth.

Horizontal. If an animal is living at 2,000 m., there is no biological barrier between any of the oceans. Therefore, it would be expected that the true abyssal animals would be cosmopolitan, and so in general they probably are. Both the fishes *Acanthonus* and *Bathymicrops* are, and further examples appear in every systematic treatment of new collections.

But there are certain striking exceptions. One example is the interesting class of Pogonophora, which have been found only in the north-west Pacific and in the equatorial Indonesian Seas. A probable explanation of this distribution could be the great variation in the food supply, which is abundant in both the areas where the Pogonophora have been found. There may well be other similar instances. It seems likely that the food supply is the most important factor governing the horizontal distribution of the true abyssal species.

The hadal species could also be governed by pressure to the extent that if a species has become barophilic, it has no possibility of spreading from one trench to another, so that each trench will tend to contain a special endemic fauna. A fine example of this was found by the late O. Carlgren of a new family of Actinaria represented by one species in the Philippine Trench and another in the Kermadec Trench (an account is in the press).

Origin

The true abyssal fauna is derived from the bathyal fauna, from which such species that can live under the higher pressure and at lower temperatures have spread downwards. Exploration of the abyssal zone has thus added but little to the list of living fossils which it was expected would be discovered when the first stalked crinoids were found more than a century ago. But the majority of stalked crinoids are bathyal, and so are the hexactinellid sponges and the eryoneid crustaceans and the coelacanth fish *Latimeria*. This bathyal distribution was clearly seen so long ago as 1899 by Perrier[9], when he suggested the name the Palæozoic zone for the depths from 400 m. to 2,000 m. because of the many similarities with the cretaceous fauna.

It seems probable, therefore, that the temperature in abyssal depths in Tertiary time and earlier, when there were no constant polar ice-caps, was between 4° and 10° as in the present bathyal zone. This agrees very well with the results of Emiliani and Edwards[10], who examined the oxygen isotopes of benthic Foraminifera of probably Oligocene age from the eastern central Pacific. They found temperatures around 10° C., where to-day it is about 2·5° C. So the relatively sudden onset of the glacial age and its cooling of oceanic deep water must have been catastrophic for the abyssal and hadal faunas. Only the relatively eurythermic and eurybathic species could survive.

The present composition of the hadal fauna may indicate the types of animals which survived; if taxons higher than subspecies are exclusively of hadal occurrence, they must be relics of a preglacial abyssal or hadal fauna. But besides these old components there must have been a new invasion, which started with the first glaciation and is presumably still going on. The lower part of the bathyal zone and even coastal waters of the polar regions have yielded species of the necessary eurybathic capacity.

The *Challenger* Expedition opened up the abyssal world eighty years ago; but hadal organisms have been known for less than ten years. Collections now being studied may soon lead to changes in some of the points of view given here; but very much more field-work must still be carried out before we have a knowledge of the abyssal and hadal zones which will stand comparison with that of coastal seas.

[1] Koczy, F. F., *Naturwiss.*, **37**, 360 (1950); *Ass. Océanogr. proc. verb.*, **5**, 146 (Bruxelles, 1952); Statens Naturvetensk. Forskningsråds Årsbok, **6**, 97 (Stockholm, 1953).

[2] Brouardel, J., and Fage, L., *C.R. Acad. Sci., Paris*, **237**, 1505 (1953); *Deep-Sea Research*, **1**, 86 (1954).

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[4] ZoBell, C. E., *Science*, **115**, 507 (1952).

[5] Krogh, A., *Ecol. Monogr.*, **4**, 430 (1934).

[6] Plunkett, M. A., and Rakestraw, N. W., *Deep-Sea Research*, **3**, Supp., 12 (1955).

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[8] Bruun, A. F., *Nature*, **168**, 692 (1951).

[9] Perrier, E., "Les Explorations sous-marines" (Paris, 1899).

[10] Emiliani, C., and Edwards, G., *Nature*, **171**, 887 (1953). Marshall, N. B., "Aspects of Deep Sea Biology" (London, 1954), contains a full list of references to the general theme.

NEWS and VIEWS

Biochemistry in the London School of Hygiene and Tropical Medicine: Prof. H. Raistrick, F.R.S.

Prof. Harold Raistrick, who retires from the chair of biochemistry in the London School of Hygiene and Tropical Medicine at the end of the current session, graduated at Leeds in 1912. There he came under the influence of J. B. Cohen, to whose training in organic chemistry so many British biochemists are indebted. He was engaged for a brief period on research on the proteins of milk and then proceeded to Cambridge, where he worked in the laboratory of Sir Frederick Gowland Hopkins and first became interested in the metabolism of micro-organisms. He was the first grantee in microbiological chemistry of the Medical Research Committee, conducting government research on the production of acetone by fermentation. After receiving the degree of D.Sc. (Leeds) in 1920, he accepted an industrial post and for eight years guided the activities of the newly formed biochemical laboratory of Nobel's Explosives Co. at Ardeer Factory, Stevenston, Ayrshire (later merged into Imperial Chemical Industries, Ltd.). Here he initiated the pioneering work on the metabolic products of the micro-fungi which was to prove the main interest of his research career.

Returning to academic life, in 1929 Prof. Raistrick was appointed to the University chair of biochemistry in the London School of Hygiene and Tropical Medicine. He was then able to publish the investigations undertaken at Ardeer in a series of eighteen papers forming the first group of "Studies in the

Biochemistry of Micro-organisms". This work received very favourable comment; the Sc.D. (Cantab.) and the fellowship of the Royal Society soon followed. The major part of his research work during the tenure of his chair has been devoted to the continuation of the studies on micro-fungi, and the contributions in this main series of papers which has flowed from his laboratory now number nearly one hundred. Prof. Raistrick has served as secretary of the Biochemical Society and has devoted much time to administrative and advisory duties in the University of London. During the Second World War he was honorary scientific adviser on penicillin production to the Minister of Supply; in 1949 he was Bakerian Lecturer of the Royal Society.

Prof. J. H. Birkinshaw

Dr. John Howard Birkinshaw, who is already reader in biochemistry in the London School of Hygiene and Tropical Medicine, is to succeed Prof. Raistrick. Like Prof. Raistrick, Birkinshaw is a graduate of the University of Leeds, eventually gaining the degrees of M.Sc. and D.Sc. from that University. In the First World War he held a commission in the West Yorkshire Regiment, took part in the Somme offensive and was captured at Delville Wood, to be repatriated shortly after the Armistice in 1918. He commenced his research career as a research biochemist in the Ardeer Factory of the Nobel's Explosives Co. Here began his long association with Prof. Raistrick, whom he succeeded as chemist in charge of the Biochemical Department at Ardeer when Raistrick moved to the London School of Hygiene and Tropical Medicine. In 1931, the senior staff of the Biochemical Department at Ardeer moved to Prof. Raistrick's department in London, where Birkinshaw remained until 1937, when he went for a year to the I.C.I. Research Station at Jealott's Hill to work on the conservation of grass protein. In the following year, he was appointed senior lecturer in Raistrick's department at the London School of Hygiene and Tropical Medicine, becoming a reader in the University of London in 1945. Dr. Birkinshaw is a Fellow of the Royal Institute of Chemistry, and has been a secretary of the Biochemical Society. The greater part of his research has been devoted to the study of metabolic products of micro-fungi, a field which he and Prof. Raistrick have together developed with great distinction.

Psychology at Oxford : Prof. G. Humphrey

When Prof. George Humphrey retires from the chair of psychology in the University of Oxford next September, he will be able to look back over the past nine years with great satisfaction. He went to Oxford in 1947, after a distinguished career in the United States and Canada, returning as a professor to the University which he had first attended as an undergraduate. Anybody who visited the Institute of Experimental Psychology, in the Banbury Road, then, and who revisits it now, will speedily realize how great a development has taken place. It is fair to say that psychology at Oxford has made more advances during these years than at any earlier period, and in particular that excellent working relations have been established with other academic studies. All is now well in train for still more striking developments. It is remarkable that, with all this, Prof. Humphrey has also found the time to complete and publish those studies in the experimental psychology of thinking for which he has now become known throughout the world.

Prof. R. C. Oldfield

Prof. R. C. Oldfield, who is to succeed Prof. George Humphrey at Oxford, took his first training at Cambridge, reading the Natural Science Tripos, Part 1, and Moral Sciences Tripos, Part 2. He was an exhibitioner in moral sciences at Peterhouse and held the Arnold Gerstenberg studentship in philosophy, and the Leverhulme fellowship in industrial psychology. For a time he worked with Prof. Cairns in Oxford on head injuries, holding a Rockefeller research fellowship. During the Second World War he was with the Radar Branch of the R.A.F., being mentioned in dispatches. After a period of lecturing at Oxford, first in general then in experimental psychology, he was called to the chair at Reading in 1950. He was a founder-member of the Experimental Psychology Group and edited the *Quarterly Journal of Experimental Psychology* for some years, and still serves as associate editor. His interests in psychology have been unusually broad, extending from applied psychology (his monograph on the "Psychology of the Interview" is well known) to the effects of head injuries and the contrivance of a number of ingenious pieces of apparatus such as that for the continuous recording of sensory thresholds. In addition, he has published many experimental and theoretical papers covering a wide range of subjects. During his six years tenure of the chair, the department at Reading has steadily increased its reputation for progressive experimental work.

Mathematics at Glasgow : Prof. I. N. Sneddon

Prof. I. N. Sneddon, of the University College of North Staffordshire, has been appointed to the newly created Simson chair of mathematics in the University of Glasgow. Named after Robert Simson, who was professor of mathematics in Glasgow during 1711–61, the new chair has been set up in order to strengthen the link between the Mathematics Department and the Faculty of Engineering. The new professor will be responsible for the mathematics courses given to students of engineering and for the advancement and exposition of mathematical methods. The need for engineers skilled in mathematical techniques of various kinds has never been greater than at the present time, and there is great scope for the holder of such a chair to meet this need and develop his subject. It would be hard to find anyone better fitted to do this work than Prof. Sneddon. Appointed at the early age of thirty to the chair of mathematics at the University College of North Staffordshire, he has been responsible for the setting up and working out of new courses of mathematics there and has still found time to carry on his own research work and write several books, as well as doing valuable work on committees of the Scientific Advisory Council. He has an impressive range of mathematical techniques at his disposal which he has applied to a wide range of subjects in applied mathematics and theoretical physics. His main work has been on elasticity, and his recent work on the generation of waves in elastic solids by variable body forces is of particular interest.

Washington University, St. Louis, Mo. : Physics Appointments

Dr. E. U. Condon, visiting professor of physics at the University of Pennsylvania, has been appointed

professor of physics and chairman of the Department of Physics of Washington University, St. Louis, Mo., in succession to Prof. George E. Pake, who has been appointed to the chair of physics at Stanford University. Dr. Condon was previously director of research and development of the Corning Glass Works during 1951–55, and before that was director of the National Bureau of Standards, Washington, D.C. In 1953 he was president of the American Association for the Advancement of Science. Two other appointments in the Department of Physics have also been made: Dr. M. W. Friedlander, of the University of Bristol, England, to be a research associate with the task of establishing a nuclear emulsion group for the study of high-energy nuclear processes; and E. B. D. Lambe, of Princeton University and the University of British Columbia, whose speciality is paramagnetic resonance, to be assistant professor of physics.

University of Durham

The University of Durham has announced the following appointments: Dr. W. B. Fisher, reader in geography, to the professorship of geography in the Durham Division; Dr. P. L. Robinson, reader in inorganic chemistry, to a personal professorship of inorganic chemistry in the Newcastle Division; Dr. E. G. Richardson, reader in physics, to a personal professorship of acoustics in the Newcastle Division; Dr. J. Weiss, reader in the mechanism of chemical reactions, to a personal professorship of radiation chemistry in the Newcastle Division.

Falkland Islands Geological Work at Birmingham

A contract has been concluded between the Colonial Office and the University of Birmingham, as a result of which the geological work of the Falkland Islands Dependencies Scientific Bureau (the director of which is Sir Raymond Priestley) will for the next three years be done in the Department of Geology at Birmingham. The primary object of this arrangement is the production of a basic geological map and evaluation of the stratigraphy and economic resources of the Dependencies. Field work in the antarctic will continue as before, under the control of the Governor of the Falkland Islands. At Birmingham, the facilities of apparatus, comparison material and library will be made available to holders of newly established fellowships, some of whom will be appointed to deal with petrological and palæontological collections already made, while others will be men who have returned from a tour of field work and will require a further year or two years to work out their results. To co-ordinate this work, the University has appointed, under the title of Senior Research Fellow in the Department of Geology, Dr. R. J. Adie, who has, among other qualifications for this position, several years of practical experience in the Dependencies, and a number of publications on their geology.

Training B.B.C. Engineers

Prior to 1946, technical training within the British Broadcasting Corporation was carried on in a number of regional studio centres and at some of the large transmitting stations. It was then found necessary to centralize engineering training at Wood Norton Hall, near Evesham, in a special department, which has just passed its tenth anniversary. The head of this B.B.C. Engineering Training Department is Dr. K. R. Sturley, formerly assistant principal of Marconi College, Chelmsford. With the completion of some new buildings this year, about two hundred students can be accommodated on full-time residential courses of training, which cover both sound and television broadcasting. Every effort is made to avoid duplicating the training in electrical engineering given in universities and technical colleges; but the application of basic principles to the equipment and methods used by the B.B.C. is studied in detail. While radio engineering normally calls for a very high standard of mathematics and technical knowledge, a feature of the B.B.C. courses is the selection and presentation of special instruction in broadcasting engineering so that it can be readily understood by staff without advanced mathematical knowledge. This involves the use of special demonstration equipment, most of which is constructed in the department's laboratories and workshops.

The various courses cover such subjects as sound recording, acoustics, studio lighting, and transmitters and aerial design for various frequencies. The courses vary in length up to twelve weeks, terminating in examinations, and the successful candidates are then eligible for promotion. A series of booklets, entitled "Engineering Training Supplements", have been prepared by the staff, dealing with such subjects as the principles of television lighting, audio-frequency amplifiers and frequency modulation; and these are used to augment the lectures and demonstrations. In the past ten years, nearly four thousand men and women have passed through the Department; and during 1956 the number attending the various courses is expected to rise to more than eight hundred.

Industrial Trade Associations in Great Britain

In a broadsheet issued last year (*Planning*, 21. No. 383; 1955), Political and Economic Planning presents a preliminary account of a new survey of manufacturers' trade associations which is being conducted in co-operation with industry. It excludes associations concerned solely with research or with labour or management and also general bodies which represent industry as a whole, and, in addition, it excludes associations consisting entirely of distributors. Besides an analysis of the services offered by associations to their members, the inquiry attempts to assess the effectiveness of trade associations' activities in representing members from the point of view of various bodies which have contacts with such associations, and it is also intended to approach many manufacturing firms to discover what trade associations mean to them in the course of their business. There appear now, in 1955, to be more than a thousand such associations in existence; of these, more than two hundred are concerned with the textile and clothing industries and more than a hundred with each of the following industries: chemicals and allied trades; metal manufacturers; metal goods; engineering and shipbuilding; and food, drink and tobacco. Two main types of general, broadly based associations covering many specific interests can be distinguished: the federation comprising local or product associations, such as the British Man-Made Fibres Federation and the Wool Textile Delegation; and the large industry-wide association which may or may not have local or product associations affiliated to it, of which the British Electrical and Allied Manufacturers Association is an example. The broadsheet lists some thirty-seven different activities undertaken by some or other associations and reviews briefly the three main aspects of their work: representation of the industry; provision of common services (including exchange of

information and experience and publicity); and economic regulation. Of the first, the broadsheet notes, besides presentation of a united front to other organizations, including government departments, the value of trade associations as a source of expert advice; of the second, that much valuable work is done in the fields of safety and health; and of the third, that not more than 15–20 per cent are concerned in any way with prices.

Taxonomy and Origins of Cultivated Bananas

A FURTHER useful and interesting contribution to our knowledge of these topics has been made by N. W. Simmonds and K. Shepherd (*J. Linn. Soc.*, Botany, **55**, No. 359, 302; 1955). Two wild species, *Musa acuminata* Colla and *M. balbisiana* Colla, are considered to be the sources from which virtually all the edible bananas have originated. Earlier investigations had led to the view that there were edible diploid and triploid forms of *M. acuminata*, of diploid and triploid forms of interspecific hybrid origin, and of triploid forms of *M. balbisiana*. Simmonds and Shepherd now point out, however, that this view of banana taxonomy presents difficulties, in that no edible diploid forms of *M. balbisiana* are known, and that, although mechanisms for the production of vigorous tetraploid bananas are well known from cytogenetic experiments, only one such banana is known to occur naturally. They have now used a taxonomic scoring method for classifying the edible bananas and to provide evidence on their evolution. Edible diploid forms of *Musa acuminata* are thought to be the primary source of the whole group to which another species, *M. balbisiana*, has contributed by hybridization. Thus there exist diploid and triploid edible forms of *M. acuminata* and diploid, triploid and tetraploid hybrid types of genetic constitutions that vary according to their histories. There is a faint possibility that a third wild species has contributed to the origins of a small group of triploid hybrid types. Triploidy was probably established under human selection for vigour and fruit size; tetraploidy is inexplicably rare. The centre of origin of the group is Indo-Malaya, and Malaya is probably the primary centre. The two Linnæan species, *M. paradisiaca* and *M. sapientum*, refer to identifiable edible varieties which are both shown here to be of hybrid origin. The names, therefore, may be rejected from the nomenclature of the wild bananas.

Poultry Housing

POULTRY keeping in England and Wales has undergone great changes since the last edition of Bulletin No. 56 "Poultry Housing" was published by the Ministry of Agriculture and Fisheries in 1935. Interest in intensive and specialized methods has much increased, and the type of housing and equipment required has been altered accordingly. A complete revision of the Bulletin has now been carried out, keeping in mind the needs of those following both the older and newer methods. The approach to the subject is essentially practical, and the Bulletin, which is now in its fifth edition (pp. 56+4 plates. London: H.M.S.O., 1955; 2*s*. 6*d*. net), contains a large number of excellent diagrams and photographs. Before describing the principles of design and construction, useful advice is given on layout, choice of building materials and the accommodation requirements of different classes of birds. Stress is laid on the importance of good ventilation, lighting and protection from extremes of weather, and practical information given as to how these needs may best be met. The Bulletin should prove helpful to poultry keepers of all types in establishing an efficient unit at a minimum cost.

Scientific Film Review

As a result of a change in publication policy by the Scientific Film Association, the *Scientific Film Review* has been issued in a new format. The change is intended to create a journal which not only contains more film reviews than were previously published annually but which also provides a means of informing members and subscribers of the activities of the Association and of developments in the production and application of scientific and industrial films. The new journal will appear every second month. Three issues each year will contain film reviews and appraisals, articles on various aspects of scientific and industrial films, and other information of interest to all concerned with the application of film to scientific and industrial problems. The other three issues will generally be devoted to films on specific subjects. The first special issue of this kind will be published in June and will be devoted to films on chemistry. The present issue (2, No. 1; April 1956) contains articles on the film and work study, first steps in industrial film making and the use and abuse of film in medical illustration. There is also a classified list of medical films which have been notified during the past two years.

Health Education in the U.S.S.R.

IN September 1955 a group of fifteen medical men went to the Soviet Union to study preventive medicine. They made a journey covering some eight thousand miles from Leningrad to Moscow, Tashkent, Samarkand, Sochi, Stalingrad, back to Moscow and finally to Leningrad. Their experiences have been recorded by Dr. John Burton (*Health Education*, 14, No. 1; March 1956). In the U.S.S.R., the doctor considers the purpose of medicine not to be the alleviation of suffering but the raising of the standard of living; prevention takes precedence over cure. The health services are not divided into cure and prevention, as they are in Great Britain, with hospitals and general practice on one side and public health on the other. Their divisions are pædiatrics, adult medicine and environmental sanitation. Prevention and cure in these fields are carried on simultaneously in the same building, namely, the polyclinic. Every health worker—nurse, physician, sanitarian or surgeon—studies health education during his or her training.

Decisions on Zoological Names for Certain Birds

THE International Commission on Zoological Nomenclature has recently taken a series of decisions on the names for certain birds regarding which applications to the Commission were published in October 1952 in Part 1/3, Vol. 9, of the *Bulletin of Zoological Nomenclature*. Among the decisions so taken, the following are of wide general interest: (1) suppression of the generic name *Colymbus* Linnæus, 1758, and acceptance of the generic name *Gavia* Forster, 1788, for the divers (loons) and of *Podiceps* Latham, 1787, for the grebes (Opinion 401); (2) validation of the generic name *Pyrrhocorax* [Tunstall], 1771, for the chough by the suppression of the name *Coracia* Brisson, 1760 (Opinion 404); (3) suppression of the specific name *ericetorum* Turton, 1807, and acceptance of the name *philomelos* Brehm, 1831, for

the song thrush (Opinion 405); (4) suppression for nomenclatorial purposes of the names by Linnæus published in 1776 in the "Catalogue of Birds, Beasts, . . . in Edwards' Natural History" (Opinion 412); (5) validation of the name *Columba migratoria* Linnæus, 1766, for the passenger pigeon (Direction 18); (6) validation of the generic names *Bubo* Dumeril, 1806, *Coturnix* Bonnaterre, 1790, *Egretta* Forster, 1817, and *Oriolus* Linnæus, 1766, by the suppression of older homonyms (Direction 21); (7) acceptance of *Gallinago* Brisson, 1760, and rejection of *Capella* Frenzel, 1801, as the generic name for the snipe (Direction 39). These decisions are being published. All inquiries should be addressed to the Publications Officer, International Trust for Zoological Nomenclature, 41 Queen's Gate, London, S.W.7.

Northern Advisory Council for Further Education

The eighth annual report of the Northern Advisory Council for Further Education shows how one of these regional organizations is stimulating and canalizing the development of technical education in its area. Growing interest in fuel efficiency, for example, has been followed not only by the further education and training of boiler-house operatives but also by the provision of a refresher course in fuel technology for works and plant engineers at Middlesbrough. Suggestions by the Ministry of Education that local authorities could usefully develop their range of advanced courses has led to the organization of *ad hoc* courses in analytical chemistry at Whitehaven, work study at Darlington, Gateshead and Newcastle, and the testing of materials and the design of fabricated structures at Sunderland. Courses projected for the 1955–56 session include one on surges at Newcastle, transistors at Workington, lubrication at Middlesbrough, and metallic corrosion and protection at Sunderland. All the authorities within the region are considering the organization of courses for industrial personnel in communications and report writing. Copies of the report can be obtained from the Secretary, National Advisory Council for Further Education, 5 Grosvenor Villas, Grosvenor Road, Newcastle upon Tyne, 2.

National Science Foundation, Washington, D.C.: Fellowships for 1956–57

The National Science Foundation, Washington, D.C., has announced the award of 775 pre-doctoral graduate fellowships and 80 post-doctoral fellowships in the natural sciences and allied fields for the academic year 1956–57. Of the former, 296 fellowships have been awarded to first-year students, 302 to students in their intermediate years, and 177 to those in their last year. The distribution among subjects is as follows: chemistry, 182; physics, 165; engineering sciences, 109; mathematical sciences, 67; zoology, 58; earth sciences, 40; psychology, 26; biochemistry, 25; microbiology, 20; botany, 16; medical sciences, 14; agriculture, 11; anthropology, 11; genetics, 7; astronomy, 7; general biology, 3; and biophysics, 3. In addition, 11 awards have been made in fields where the natural sciences converge with the social sciences. Of the post-doctoral awards, 29 have been made in the life sciences, 19 in chemistry, 13 in the mathematical sciences, 9 in physics and astronomy, 5 in the earth sciences, and 2 in the engineering sciences. All the awards are tenable at any accredited non-profit educational institution of higher learning in the United States or abroad. The pre-doctoral fellowships are worth 1,400 dollars for the first year, rising to 1,800 dollars for those in their last year, and post-doctoral fellowships are worth 3,400 dollars. The fellowships include additional allowances for dependants, tuition and other normal expenses.

Oversea Service Division, Colonial Office

The following appointments have recently been made in the Oversea Service Division, Colonial Office: G. W. Anderson (agricultural officer, Uganda), senior agricultural officer, Uganda; D. G. Jones (agricultural officer, Tanganyika), assistant director of agriculture, Tanganyika; D. K. Jones (agricultural officer, Cyprus), senior agricultural officer, Cyprus; R. B. Smith (agricultural officer, Trinidad), agronomist, Trinidad; R. B. Warner (senior agricultural officer, Western Region, Nigeria), principal agricultural officer, Western Region, Nigeria; C. C. Webster (chief research officer, Kenya), deputy director of agriculture, Federation of Malaya; J. D. Yelf (agricultural officer, Northern Rhodesia), senior agricultural officer, Fiji; W. V. Calder (assistant conservator of forests, Tanganyika), assistant conservator of forests, Uganda; W. H. Jack, J. W. C. Mooney, D. Sim, J. W. Wheelan and J. C. Wilson (assistant conservators of forests, Gold Coast), senior assistant conservators of forests, Gold Coast; H. A. Douglas, D. C. Duff and D. A. Lane (senior assistant conservators of forests, Gold Coast), conservators of forests, Gold Coast; D. Moore (assistant conservator of forests, Trinidad), deputy conservator of forests, Trinidad; P. C. Randell (senior assistant conservator of forests, Northern Region, Nigeria), conservator of forests, Northern Region, Nigeria; J. H. N. Smith (assistant conservator of forests), conservator of forests, Northern Rhodesia; A. E. G. Storrs (assistant conservator of forests, Gold Coast), assistant conservator of forests, Northern Rhodesia; I. G. Hughes (geologist, Gold Coast), senior geologist, Gold Coast; G. C. Billington (senior statistician, Gold Coast), deputy statistician, Gold Coast; J. M. Simmond (statistician, Gold Coast), senior statistician, Gold Coast; W. Stewart (senior pharmacist, Eastern Region, Nigeria), chief pharmacist, Eastern Region, Nigeria; A. E. H. Phillips, technical publications officer (agriculture), Federation of Nigeria; M. Dagg, scientific officer, East Africa High Commission; Miss S. J. Darke, medical research officer, grade III, East Africa High Commission; G. B. Aneuryn-Evans, statistician, Federation of Nigeria; P. Durran, veterinary officer, Northern Region, Nigeria; J. McP. Fletcher, assistant director of agriculture (veterinary and animal husbandry), British Guiana; A. D. Morris, veterinary officer, Western Region, Nigeria; D. A. Richardson, veterinary officer, Nyasaland.

Royal Society of South Africa: Officers

The following have been elected as officers and members of council for 1956 of the Royal Society of South Africa: *President*, S. H. Haughton; *Honorary General Secretary*, W. J. Talbot; *Honorary Treasurer*, N. Sapeika; *Joint Honorary Editors*, W. J. Copenhagen and A. M. Talbot; *Honorary Librarian*, E. Newbery; *Other Members of Council*, W. F. Barker, H. B. S. Cooke, J. H. Day, A. J. H. Goodwin, S. M. Naude, W. S. Rapson, S. H. Skaife and R. H. Stoy.

Royal Aeronautical Society: Officers

The following have been appointed officers for 1956–57 of the Royal Aeronautical Society: *President*,

E. T. Jones; *Past Presidents*, N. E. Rowe, Sir Sydney Camm and Sir William Farren; *President-elect*, G. R. Edwards; *Vice-Presidents*, Sir Arnold Hall, P. G. Masefield and Dr. E. S. Moult; *Honorary Treasurer*, Major G. P. Bulman; and *Secretary*, A. M. Ballantyne.

Rutherford Memorial Lecture and Scholarship

UNDER the terms of the scheme to commemorate the late Lord Rutherford of Nelson, the Council of the Royal Society has appointed Prof. E. N. da C. Andrade to deliver the Rutherford Memorial Lecture for 1957 in Australia.

The Council of the Royal Society has also appointed Mr. A. M. Segar, a graduate of the University of Melbourne, as a Rutherford Scholar for three years from October 1, to carry out studies in nuclear physics at the University of Birmingham.

Human Problems of Industrial Communities within the British Commonwealth

A STUDY conference on "The Human Problems of Industrial Communities within the Commonwealth and Empire", under the presidency of H.R.H. the Duke of Edinburgh, and with Sir Harold Hartley as chairman, will be held in Oxford during July 9–27. The purpose of the conference is to conduct a practical study of the human aspects of industrialization, and in particular those factors which make for satisfaction, efficiency and understanding, both inside industrial organizations and in the everyday relations between industry and the community around it. It will not deal, however, with those matters which come within the normal scope of industrial negotiation. As the conference is independent in character, no government or organization is represented officially, and the members have all been invited as individuals and not delegates. About 280 men and women will be attending, mainly 25–45 years old, and all of them responsible persons engaged in the manager/employer or trade union/operative roles of industry (including industrially organized agriculture and government-owned undertakings). The approximate distribution of membership is: Great Britain, 90; Canada, 30; Australia, 25; India, 25; Union of South Africa, 18; Malaya and the Far East, 14; Caribbean area, 13; Federation of Rhodesia and Nyasaland, 12; Pakistan, 12; West Africa, 11; New Zealand, 10; East Africa, 7; Oceanic areas, 7; and Ceylon, 6. The conference will be divided into twenty study groups of fourteen members each, and after the introductory sessions they will set off for nine days on independent tours of industrial centres in Britain. The last five days of the conference will be spent in Oxford, when the final reports of each group will be discussed. Further information can be obtained from the conference secretary, Peter Parker, 48 Bryanston Square, London, W.1.

Announcements

THE Warner Memorial Medal of the Textile Institute has been awarded to Dr. J. M. Preston, research manager of British Enka, Ltd., of Aintree. The Medal was inaugurated in 1930, in memory of the late Sir Frank Warner, a past president and chairman of Council of the Institute, and is awarded for outstanding work in textile science and technology, the results of which have been published, and particularly for work published in the *Journal of the Textile Institute*.

THE Salters' Company has elected the following to be Salters' Fellows for the year 1956–57: F. W. Eastwood and R. C. Sheppard (Department of Organic Chemistry, Cambridge); Dr. L. Keay (Queen Mary College, London); and Dr. M. J. Stephen (continuation of fellowship for 1955–56; Department of Mathematics, Oxford). Salters' scholarships have been awarded to the following: A. R. Sanderson (King's College, Newcastle upon Tyne); P. S. Houston (Battersea Polytechnic, London); A. A. Webb and P. L. Levine (Imperial College of Science and Technology, London); and B. B. Hunt (University of Cambridge).

SIR K. S. KRISHNAN, director of the National Physical Laboratory of India, New Delhi, will give a lecture at the Royal Society on June 28 at 4.30 p.m. in which he will give a short account of the scientific and technical work done in the various divisions of the Laboratory. The lecture is open to the public, who should write beforehand, however, to the Assistant Secretary, Royal Society, Burlington House, London, W.1, notifying their intention to be present.

THE Manchester Joint Research Council is holding a meeting on "Automation" in the University of Manchester on July 9. The meeting will be addressed by the Earl of Halsbury. Further information can be obtained from the Council, c/o Manchester Chamber of Commerce, Ship Canal House, King Street, Manchester 2.

THE Nutrition Society is holding a symposium on "Grassland and the Feeding of Livestock" in the University of Reading on July 20, under the chairmanship of Prof. H. D. Kay. Further information can be obtained from the honorary programmes secretary of the Society, Dr. R. J. L. Allen, c/o Beecham Foods, Ltd., Brentford, Middlesex.

THE Plant Breeders' Conference organized by the Agricultural Research Council will be held this year in the Plant Breeding Institute, Cambridge, during July 4–5. About a hundred representatives are expected to attend, including the staffs of plant breeding institutes, other plant breeders and geneticists from university departments.

A SYMPOSIUM on "Chemisorption", organized by the Chemical Society, will be held in the University College of North Staffordshire, Keele, during July 16–19. After an opening session on the theory of chemisorption, there will be four sessions dealing with chemisorption on insulators, metals, carbon and semiconductors, respectively. The fee for the symposium is 2 guineas (10*s.* for Fellows of the Society). Registration forms, to be returned by July 1, and further information can be obtained from the General Secretary, Chemical Society, Burlington House, London, W.1.

THE Non-Destructive Testing Group of the Institute of Physics will hold its summer meeting during July 11–14 in the H. H. Wills Physical Laboratory, University of Bristol, when the subject will be "Physics of Some New Aspects of Non-Destructive Testing". The proceedings will be published later as a supplement of the *British Journal of Applied Physics*. The conference will be open to non-members of the Group. Enrolment forms, to be returned by June 25, can be obtained from the Deputy Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1.

THE GROWTH OF LEAVES

THE University of Nottingham held its third Easter school in agricultural science during April 23–25. It took the form of a discussion, with demonstrations, on leaf growth. Prof. F. G. Gregory (Imperial College, London) opened the symposium by outlining some general aspects of leaf growth. The initiation of leaf primordia poses certain questions, especially if a hormone theory is invoked, since two groups of cells arise from the same apex—one forms a leaf capable of only limited growth and the other the axillary bud with the potential of unlimited growth. Cessation of cell division restricts the growth of the leaf, the size of which is determined by the number of primordial cells, the rate and duration of division and the size of the mature cells. Analysis of the growth curves of leaves can assist in understanding the way in which various factors influence leaf development. Temperatures below the optimum, for example, mainly influence the rate of growth of the primordia. A photochemical reaction is involved in the production of specific leaf-forming substances; but the nature of the reactions involved in leaf growth is little understood. Prof. E. Bünning (University of Tübingen) pointed out that capacity for division and unlimited growth are common properties of protoplasm, but that these are restrained by polarity and the close proximity of meristematic areas. Meristemoids arise in areas sufficiently removed from other meristems, and these in turn tend to suppress this tendency to unlimited growth. The self-duplication of substances produced by developing cells is responsible for the stable organization and ordered differentiation of the plant. The changes which occur during the growth and differentiation of cells were described by Drs. J. K. Heyes and R. Brown (Agricultural Research Council Unit of Plant Cell Physiology, University of Oxford). Cell enlargement is not simply the expansion of a metabolic system of constant pattern but involves a system in which the pattern itself changes. Metabolic activity is low in meristematic cells due to a high proportion of protein with low catalytic activity. During expansion, the relative proportion of catalytically active protein as well as the total protein increases, and there are changes in the activity of different enzymes which determine the rate and course of growth.

The inception of leaf primordia in several different plants was described by Prof. C. W. Wardlaw (University of Manchester). The position of inception of the primordium and its symmetry, orientation and rate of growth are regulated by the activity of the apex as a whole and can be disturbed by surgical and chemical treatments. There is need for much closer study of the constitution and metabolism of cells in the different regions of the apex, since these determine the formation of growth centres and control the geometrical pattern of leaf arrangement. This arrangement, or phyllotaxis, was rigidly defined by Dr. F. J. Richards (Imperial College, London), who indicated alternative methods of estimating phyllotaxis height. An equation was also derived which has wide applications to growing and dividing systems generally. In one form it yields a relation between the cross-sectional area of an apex, the slope of the apical surface relative to the longitudinal axis, the primordial insertion area, the plastochrone, and the difference between two transverse growth-rates; it then consists of two parts, each of which represents the phyllotaxis height corresponding to the particular plastochrone considered. The metabolic changes in such a system were examined by Drs. N. Sunderland, J. K. Heyes and R. Brown (Agricultural Research Council Unit of Plant Cell Physiology, University of Oxford). Such changes may be regarded as a consequence of the primary differentiation from the apex of the tunica with low metabolic activity and the corpus with high activity. Cell division and protein accumulation are restricted in the corpus; but substrates are transferred from it to the tunica to supply materials for the rapid division and protein synthesis which occurs in this region of low inherent synthetic activity. A similar pattern occurs during development of the leaf primordium when metabolic activity increases from a low to a high level.

The changes which occur at different stages during expansion, producing a variety of different leaf forms, were outlined by Dr. H. Jones (University College, Aberystwyth). In juvenile leaves the primordial form persists to maturity; in other leaves, changes may occur at an early stage of development and may also be related to changes in width of the shoot apex. Changes in shape during expansion result from localized differences in divisions and growth; these may be analysed by using the allometric relation. Size and shape may be altered by various physical and chemical agents. From defoliation experiments with apple, Mr. H. W. B. Barlow and Mr. C. R. Hancock (East Malling Research Station) postulated that at least three different substances or groups of substances are produced by leaves and influence the growth of other leaves. One of these groups probably consists of the major photosynthetic products, a second is a factor (or factors) produced by immature leaves which influences internode extension, and the third a leaf-growth factor which influences cell division. The influence of length of day on leaf development was discussed by Prof. E. Bünning (University of Tübingen). Short days accelerate leaf production by long-day plants and retard it in short-day plants, but the rate of ageing of leaves of both types is hastened in long days. Although there is little difference in the total growth made during the light and the dark period, there are definite fluctuations in growth-rate during these periods, the maximum occurring at different times depending on the species. Prof. W. T. Williams (University of Southampton) discussed the association of light with leaf growth in terms of the etiolation phenomena of leaf suppression and internode extension which is exhibited in its absence. Suppression of etiolation by brief flashes of light is associated with the initiation of cell division; but the amount of division set in train is out of all proportion to the light stimulus given. It appears that the synthesis of leaf proteins is automatically initiated by a brief period of light; the process once started continues, irrespective of further light.

During the final session, the effect of external factors on leaf growth was discussed. Prof. F. L. Milthorpe (University of Nottingham) emphasized that most changes occur during the primordial stage. Although low temperature retards all processes,

differentiation of primordia appears to continue at a higher rate than does the rate of division and expansion of cells leading to growth of a leaf. The stage of growth is also important; following a temperature check, a higher relative growth-rate of leaves occurs if some leaves have expanded than if no leaves are present. The influence of conditions at germination persists long into the growing period. Prof. G. E. Blackman (University of Oxford) discussed the effects of light and temperature on leaf growth. These vary with the species: reduction of light intensity below full spring and summer daylight may have little effect on the leaf area of one group of plants; in another group, there may be a large increase in leaf surface with reduced light almost to the compensation point; whereas in a third the effect may be intermediate. There is, in general, a direct curvilinear relation of net assimilation-rate and an inverse relation of the leaf area ratio with light intensity; the resultant effect on relative growth-rate, being the product of these terms, depends on the magnitudes of the responses involved in these two relations. The retarding effect of increasing light on leaf expansion occurs with intensities greater than 300–600 ft.-candles; at lower intensities there is a positive effect. Leaf area increases with temperature up to about 25° C., but interactions occur between different levels of temperature and light. Dr. H. L. Penman (Rothamsted Experimental Station) showed that the growth of grass is closely proportional to the total energy supplied at the surface, and also to the potential transpiration. Water becomes limiting at small values of soil moisture deficit; these values are smaller with low than with high nitrogen supply. The slope of the curve relating growth to incoming radiation is also influenced by the nitrogen-level. Dr. D. J. Watson (Rothamsted Experimental Station) emphasized the general conclusion that the variation in dry-weight yield per acre is determined mainly by leaf growth. Variations in the rate of photosynthesis have little influence. The maintenance of dense leaf coverage during the major portion of the growth period provides the main possibility of increasing yield. There is a limit, however, to the increase in returns possible, as mutual shading of leaves ultimately reduces the net assimilation-rate sufficiently to offset the gain from the larger leaf surface. Yield of grain depends largely on a large leaf area during grain formation.

The points raised in the papers were vigorously discussed, and some of the conclusions and techniques used were demonstrated. Full proceedings will be published elsewhere. F. L. MILTHORPE

FRESHWATER BIOLOGY IN SCOTLAND

THE symposium during April 9–10 on freshwater biology in Scotland, arranged by the Institute of Biology (Scottish Branch), was the first occasion when a comprehensive survey of the progress of work on Scottish fresh waters has been presented. This being so, it is natural that it should cover a wide diversity of subjects. Subjects which ranged from the effects of hydroelectric schemes on migratory fish to the emergence of aquatic insects were submitted for discussion by speakers from the Universities of Edinburgh and Glasgow, the Brown Trout Research Laboratory, Pitlochry, the Oceanographic Laboratory, Leith, and the North of Scotland Hydro-electric Board. The topics brought forward for discussion in the first two sessions were not unrelated, and most can be fitted into a sequence commencing with conditions for life in Highland waters and passing to ecological aspects of the flora and fauna.

It was reported that streams of the catchment areas of Highland lakes and rivers are markedly subject to excessively rapid run-off, partly due to the removal of vegetation by clearing of timber and the burning of moors and partly also to extensive channel draining of sheep pastures. When peat is exposed it is not as efficient a water store as might be supposed. Rainfall reduces the surface layer to a colloidal gel, which inhibits deeper penetration and enhances rapid surface drainage into water-courses, which, in their upper reaches, usually flow down steep slopes. The result is extensive erosion in the lower reaches under storm conditions. Rapid drainage and influx of peat derivatives into Scottish lakes are contributory to the main cause, the mineralogical nature of the Highlands, of the paucity of plant nutrients in these waters. More than half those studied have a calcium content (expressed as $CaCO_3$) of less than 10 p.p.m. and nearly all have less than 50 p.p.m. They have not evolved to a degree of eutrophy permitting the reversible oxidation-reduction process described by Ohle[1] and Mortimer[2], with the result that plant nutrients tend to be occluded in the bottom muds and their main source lies in the small amounts brought in by inflowing streams.

Studies on phytoplankton in Scottish lakes, especially the application of Nygaard's[3] 'compound quotient' to a general survey, emphasize the oligotrophic nature of the majority. This quotient, which is the number of species characteristic of eutrophic waters (for example, species of Chlorococcales and Myxophyceae) divided by the number of species characteristic of oligotrophic waters (for example, species of Desmidaceae), displays a correlation with chemical evidence and with productivity of bottom fauna. Where past records exist, it has been possible to demonstrate the rate of evolution of a lake. Loch Leven, in Fife, with a quotient of 2, fifty years ago ranked as mesotrophic. To-day, with a quotient of 8, it is eutrophic. Loch Lomond, on the other hand, has shown no change over the same period.

Known in England only in the Lake District, the cladoceran crustacean, *Holopedium gibberum*, is absent from eutrophic waters but abundant in many oligotrophic lakes in Scotland. The conditions governing its distribution are not yet fully understood, for it is absent from some water bodies which appear to be closely similar to those in which it does occur. A possible clue to the uneven distribution is the presence of a certain minimum amount of dissolved organic material in the water.

The impermanence of fresh waters was discussed from another aspect, that of their invasion by pulmonate gastropods. It was suggested that the co-existence of pulmonates with a wide range of adaptations, from the great phenotypic plasticity and high ratio of selection—that is, number of individuals surviving to breed annually—of *Lymnaea peregra* to the great genotypic specialization and low ratio of selection of *Ancylus fluviatilis*, may be credited to the instability of freshwater habitats relative to their marine counterparts.

In papers on freshwater fishes and their parasites, during the second day of the meeting, interest lay in new or little-known occurrences in Scotland. Among

endoparasites of fishes, the strigeid trematode, *Cotylurus erraticus*, was reported to form massive metacercarial infestations around the heart of powan, *Coregonus clupeoides*; with an incidence of 100 per cent in Loch Lomond but apparently absent from these fish in Loch Eck, their only other habitat. Present also in trout from Lochs Lomond and Leven, *Cotylurus* does not attain in them the same high infestation. This difference in degree of infestation may be related to differing habits of the hosts, in that trout are fluviatile for at least their first year, whereas *Coregonus* spends its whole life in the lake.

The pseudophyllidean cestode, *Triaenophorus nodulosus*, occurs in pike in Loch Lomond, and its finding constitutes the second record for Britain. Since plerocercoids of this species have been found only in yearling pike, it would appear that the life-cycle is dependent on cannibalism. Apart from the consideration of their parasites, pike were shown to have a phase in development which is probably the retention of an archaic actinopterygian characteristic. The embryos hatch when the branchial region, pectoral fins and mouth are still imperfectly developed and, for a period of about ten days, hang suspended from water plants. They are attached to the support by the secretion of two cement glands placed in front of the eyes.

An addition to the Scottish fauna was established among the fishes. A biometrical study of char, *Salvelinus alpinus*, recently discovered in Loch Eck, Argyll, yielded results which give this fish the rank of a distinct sub-species.

[1] Ohle, W., *Naturwiss.*, **25**, 3 (1937).
[2] Mortimer, C. H., *J. Ecol.*, **29** (2), 49 (1941).
[3] Nygaard, G., *Kon. Danske Videnskabernes Selskab., Biol. Skr.*, **7** (1) 293 (1949).

CHEMISTRY OF OXYGENATED HETEROCYCLIC COMPOUNDS

INTERNATIONAL COLLOQUIUM AT LYONS

LESS than two months after the Dublin symposium on naturally occurring pyrones (see *Nature*, 176, 637; 1955), a similar meeting, devoted more particularly to naturally occurring flavonoid compounds, was held in Lyons during September 5–10. Twenty-six scientists from ten different countries took part in these discussions, during which the different aspects of the chemistry of oxygenated heterocyclics were reviewed.

The first series of reports were in the field of organic chemistry. M. Mousseron (Montpellier) discussed the reactions of epoxides in relation to their steric structure. He suggested a new method for their quantitative estimation in the presence of —SCN ions. The fixation of water by epoxy-1 : 2-*cyclo*alkanes was discussed. The epoxide structure occurs in the transition states of many reactions and leads to compounds having a *trans* configuration.

G. Sandris and G. Ourisson (Paris) discussed the synthesis and properties of 2 : 2 : 5 : 5-tetramethyltetrahydrofuran. Mention was made of the effect, on the spectral properties of this type of compound, of replacement of the heterocyclic oxygen by methylene. In some cases, for example, when there was an α-diketonic group in the 3- or 4-position, the authors achieved a molecular rearrangement to a four-membered ring (trimethylene oxide).

The chemistry of coumarins in general was reviewed by N. P. Buu-Hoï (Paris). The most reactive position in coumarone is the 2-position, while in thionaphthene it is at the 3-carbon. A molecule like brasane is far less reactive than the analogous polycyclic hydrocarbon (naphthacene).

C. Mentzer (Lyons) gave an account of the synthetic methods leading to benzopyrone compounds (coumarins, chromones, flavones and their derivatives). The methods were classified according to linkages formed. The condensation of an aromatic C_6 group with C_3 molecules was discussed in detail. A complete list of coumarins, chromones and flavanones, obtained by the author and his collaborators by the 'thermal condensation' of phenols with malonic or β-ketonic esters, was given.

A. Dreiding (Zurich) has synthesized 5 : 6 : 7 : 8-tetrahydrocoumarin by a Reformatsky reaction between ethyl monobromacetate and 2-(hydroxymethylene)-*cyclo*hexanone. It may be possible to apply this method to the synthesis of other α-pyrones starting from β-dicarbonyl derivatives.

In a second series of papers, the oxygenated heterocyclics were discussed with emphasis on the biochemical aspects. As in the Dublin symposium, the flavones and their derivatives, as well as other less well-known lactones, were the focus of attention.

T. R. Seshadri (Delhi) showed the possibility of the *in vitro* transformation of flavanones into dihydroflavonols by the addition of an oxygen atom to the 3-position. This can be achieved: (*a*) by bromination or iodination of the acetyl derivative of the flavanone and subsequent treatment with silver acetate; (*b*) by the action of lead tetra-acetate; (c) by the action of Fenton's reagent (hydrogen peroxide + ferrous ion) on the acetyl derivatives.

T. S. Wheeler and E. M. Philbin (Dublin) discussed molecular rearrangements in the flavonoid field. The Wessely–Moser rearrangement has been extended to chromanols and dihydroxyxanthones. A new type of rearrangement was described in which the 2-aryl nucleus takes the place of the second benzene nucleus in the flavone molecule.

The chemistry of natural aurones was reviewed by T. A. Geissman (Los Angeles). These substances (benzal-2-coumaranones) occur in many higher plants of the genera *Cosmos*, *Coreopsis*, etc. The author, who recalled the work of Marini-Bettolo, Hattori and others, has studied their synthesis, properties, detection in plants, isolation and spectral properties in relation to structure.

S. Hattori and M. Shimokoriyma (Tokyo) presented two reports, one dealing with flavonic glycosides from the leaves of *Calystegia japonica* and *hederacea*, the other on the localization of the flavonoid pigments in '*Cosmos sulphureus*'. It is interesting to note that *Calystegia japonica* Choisy (Convolvulaceae) contains a rhamnoglucoside of kæmpferc', in which the disaccharide unit located in position 3 has been identified as rutinose, while *Calystegia hederacea*, a species so similar as to be easily mistaken for the former, contains kæmpferol 3-galactoside identical with trifolin from the flowers of *Trifolium repens*.

Dihydroflavonols were discussed by J. Gripenberg (Helsinki). These compounds are of interest because of the manner in which they become rearranged in alkaline media. In contrast to what happens in aurones, the rearrangements of dihydroflavonols are accompanied by contraction of the heterocyclic ring.

T. Swain (Cambridge), in the course of investigations on the chemical composition of some horticultural varieties of *Dahlia variabilis*, has found that the petals and leaves of some of these plants contain aglycones, which have not hitherto been discovered in this species, namely, sulphuretin, 2′ : 4 : 4′-trihydroxychalkone, naringenin, eriodictyol, quercetin and kæmpferol.

H. Erdtman (Stockholm) outlined the comparative biochemistry of the genus *Pinus*. The following flavonoid constituents have been identified in extracts of the heartwoods of these species : chrysin, tectochrysin, 6-methylchrysin, 2 : 3-dihydrochrysin, 2 : 3-dihydrotectochrysin, pinobanksin, pinobanksin 7-methyl ether, strobopinin, cryptostrobin, and strobobanksin. Here the distribution of these substances shows a positive taxonomic interest. Botanists divide the genus *Pinus* into two parts, namely, diploxylon and haploxylon. In the diploxylon species, no flavones are encountered, only flavanones occur ; in the haploxylon species, however, flavones and flavanones exist simultaneously.

F. E. King (Nottingham) has isolated derivatives of the catechin group (3-hydroxyflavans) in the heartwoods of many species of *Afzelia*. He re-examined classical views concerning the structure of such derivatives and, in the light of present stereochemical theory, he concludes that the 'epi' series should have a 'cis' configuration. Melacacidin, another component isolated from the wood of *Acacia melanoxylon*, has been identified as 7 : 8 : 3′ : 4′-tetrahydroxyflavan-3 : 4-diol and must be considered as a typical leucoanthocyanidin.

H. Schmid (Zurich) dealt with the chemistry of non-benzopyronic lactones. He described their chemistry and physical properties in relation to molecular structure. Various methods of determining the nature of the heterocyclic ring (pentagonal or hexagonal), the number and positions of the double bonds, etc., were given. He reviewed some naturally occurring well-defined types, for example, protoanemonin, kawain, nepetalactone, etc.

W. Whalley (Liverpool) spoke about sclerotiorin and rotiorin, which are pigments obtained from several strains of *Penicillium sclerotorum*. They have the empirical formulæ $C_{21}H_{23}O_8Cl$ and $C_{21}H_{22}O_8$, respectively, and both contain the same branched C_9 ethylenic chain. They almost certainly possess an α-pyrone ring characterized by the fact that the heterocyclic oxygen can be replaced by —NH— with subsequent formation of the corresponding α-pyridone.

The structure of calophyllolide, a compound isolated from the nuts of *Calophyllum inophyllum*, was discussed by Mme. Polonsky (Paris). This has the empirical formula $C_{28}H_{32}O_5 \pm CH_2$. It is an αβ-unsaturated-γ-enol-lactone having one methoxyl group. With 40 per cent potassium hydroxide it gives 5-hydroxy-7-methoxy-4-phenylcoumarin ($C_{16}H_{12}O_4$), the structure of which was confirmed by comparison with an authentic sample.

A third series of reports were devoted to analytical work.

Mme. G. Aulin-Erdtman (Stockholm) described the Δε method and its possible application to the analysis of flavone and flavone derivatives. This method is based on the modification of the ultraviolet spectra caused by ionization or other convenient chemical reactions. The change in ε-values determined at various wave-lengths (λ) is represented graphically, giving a Δε curve. This curve is a characteristic of the chromophore, which can be modified and is independent of non-reactive chromophores. The method is sometimes better than ordinary ultra-violet examination in analysing complex natural extracts.

Finally, two papers dealing with the biological properties of oxygenated heterocyclics were presented.

F. Tayeau (Bordeaux) has shown that leucocyanidol, isolated from the teguments of the arachid nut, increases vascular resistance both in animals and in men. Moreover, it possesses anti-anaphylactic properties which might be explained by its inhibitory power towards hyaluronidase. It is fixed by seric proteins, more particularly by the globulin fraction. At a certain concentration it induces formation in serum of a precipitate containing all the lipids and only very small quantities of proteins.

H. Ferrando and J. Bost (Lyons) have studied the action *in situ* of several flavones on the intestines of rabbits. Ferguson has already shown that tricin (5 : 7 : 4′-trihydroxy-3 : 5-dimethoxyflavone) strongly inhibits contraction of this organ. Its 4′-methoxy derivative, on the contrary, reduces the effects of tricin.

It will be seen from the summaries that much current work in the field of oxygenated heterocyclics was presented at this colloquium. It is to be regretted, however, that a number of centres of research in the United States, Australia, Africa and Asia could not, owing to geographical considerations, send representatives to the colloquium.

ANIMAL SOUNDS IN THE SEA

DURING the Second World War the ocean waters were widely explored for the first time with sensitive listening devices. Submarine eavesdroppers heard sounds which they took to be from ships where there were no ships, and many mysterious 'beeps', 'groans', 'croaks', 'crackles', 'whistles' and 'moans' came to their earphones. It was suspected that these noises were the chatter of underwater animals, and, after the War, the U.S. Office of Naval Research launched a comprehensive study of sea-animal sounds. This study has been reported by Marie Poland Fish (*Sci. Amer.*, April 1956).

Scientific workers have listened with hydrophones and recorded on tape the sounds of hundreds of species of animals, from shrimps to porpoises. The articulate denizens of the sea 'speak' a confusing variety of dialects, but each is distinctive, and with experience it is possible to identify the kind of animal by its sounds, as one recognizes a familiar voice on the telephone. Listening to tropical fishes in the waters of the Caribbean, trained recorders can recognize them on approach before they come into view. Fishes and other sea animals have no vocal organs : they make sounds in diverse and intriguing ways which sometimes involve a large part of the anatomy.

One group produces sound by vibrating the walls of their balloon-like air bladder, the bladder acting like a sound-box or drum. The toadfish, for example, sets up vibrations of its bladder by means of muscle contractions, and the sound emitted ranges from a grunt to a 'fog-horn' boom. Experiments have shown that the sound originates in the air bladder. When the bladder was removed, the fish could produce no sound. But the air bladder alone, placed

in a jar of sea water and stimulated by electricity, emitted grunts which were typically 'toadfish' to the ear.

A second class of sound-makers produce noises by scraping one body part against another; this is particularly common with the 'teeth-grinders'. The squirrelfish, for example, grinds together toothed areas in the back of its mouth, called gill teeth, and so generates a sound which is amplified by the adjacent air bladder and becomes a rasping grunt.

One of the most puzzling sounds which was encountered was that of the sculpins, a family of spiny sea fishes like the freshwater bullhead. These fishes issue a dull low-pitched drone which suggests the hum of an electric generator. The sculpin has no air bladder, and it was difficult to understand how the fish produced its sound. Examination of its anatomy and recent experiments suggest that the noise is made by rapid vibration of muscles attached to certain bones in its skeleton.

The most garrulous fish is the sea robin. Most fishes try to make a silent escape when something strange approaches. This is not the case with sea robins, which keep up a barrage of grunting and cackling—disturbed or undisturbed. A tame sea robin in an aquarium clucks softly when stroked, like a purring cat, but if handled too much will break away in seeming annoyance and emit a burst of noise. Other fishes appear to be noisy only when noise is called for. With the approach of a ship, fishes usually cease their chatter instantly.

Fish apparently make noises for a great variety of reasons. They use sound to communicate. Squirrelfishes, which are inclined to be nocturnal; eels and catfishes, which live in muddy, murky waters; croakers, which become most active after sunset—these and similar species must find sound useful for aggregating. Many fish become most loquacious during the spawning season.

Competition seems to be a common stimulus to sound. Sprinkling of food in a tank of sonic fishes incites a general noisy commotion.

Experiments have indicated that sea horses may use sound for orientation. During the first few days of captivity they make vigorous snapping noises, apparently associated with the strangeness of the new environment.

Of the more primitive forms of life, the shrimps make most noise. The combined popping of thousands of shrimps in their unseen beds makes a crackling chorus day and night. Experiments indicate that this noise accompanies the ejection of jets of water which the shrimps use for offence and defence.

In the case of marine mammals, the noises of whales and porpoises may be heard all over the oceans. The noises have been described as "propeller or screw noises", and clucking and squealing sounds covering the whole sound band and 'pings' suggestive of echo-ranging.

Learning sea sounds and languages has certain practical uses. Already the U.S. Navy has found the research helpful for predicting underwater sound conditions in strategic areas, for developing underwater acoustic gear and for training sonar operators. Commercial fishermen are using acoustic finders to locate schools of fish. They would like 'hearing aids' which could spot concentrations of food fish, identify them by their sounds and track their movements in bird-dog fashion. It may eventually be possible to use stationary, remotely controlled listening posts, comparable to sonar buoys, which will detect and broadcast the position of migratory fishes.

CHELATING AGENTS AS PLANT GROWTH SUBSTANCES

A POSSIBLE CLUE TO THE MODE OF ACTION OF AUXIN

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THE observation which gave rise to this work was made during an attempt to prevent the inhibiting effect of chromatographic paper on the growth of wheat coleoptile sections in the straight growth test as modified by Hancock and Barlow[1]. It was found that acid-washed paper, treated with ethylenediaminetetra-acetate (EDTA) and washed, caused significantly more growth than occurred in the complete absence of paper. An experiment was therefore carried out without any paper, in which EDTA was given at concentrations of zero and 10^{-10} to 10^{-5} *M*, both with and without 10^{-5} *M* 3-indolylacetic acid (IAA). It was found that after 19 hours 10^{-5} *M* EDTA alone gave practically the same increment of growth compared with controls as did 10^{-5} *M* IAA alone, and even 10^{-10} *M* EDTA alone apparently caused some increase.

In this experiment the interaction between IAA and EDTA did not approach statistical significance ($P \simeq 0{\cdot}2$), consistent with the hypothesis that their effects were independent and additive.

Similar experiments were then carried out using seven chelating agents, of very various molecular structure, at concentrations of zero, 10^{-9} *M*, 10^{-7} *M* and 10^{-5} *M* in combination with zero and 10^{-5} *M* IAA. It was found that all the agents tried could act as growth substances, namely, EDTA, uramildiacetic acid (UDA), anthranilic acid diacetic acid (AADA), nitrilotriacetic acid (NTA), iminodiacetic acid (IDA), 8-hydroxyquinoline (8HQ) and sodium diethyldithiocarbamate (DIECA). It was found that although DIECA, a heavy metal enzyme inhibitor, could act as a growth-promoting substance, another such inhibitor, namely, potassium cyanide, which was not a chelating agent, depressed growth at the same concentrations. In this series of experiments no indications of interactions with IAA were found,

Table 1. Mean Length (cm.) of Wheat Coleoptile Sections, originally 1 cm., after 19 hours at 25° C. (1.12.55). Five Replicates, each of Five Coleoptiles

	EDTA:	0 *M*	10^{-10} *M*	10^{-9} *M*	10^{-8} *M*	10^{-7} *M*	10^{-6} *M*	10^{-5} *M*
IAA	0 *M*	1·81	1·91	1·91	1·93	1·95	2·02	2·05
	10^{-5} *M*	2·06	2·06	2·07	2·07	2·08	2·13	2·25
	Mean	1·94	1·99	1·99	2·00	2·02	2·08	2·15

Significant difference (P 0·05) for means of + and − IAA = 0·055

Table 2. Mean Length (cm.) of Wheat Coleoptile Sections (originally 1 cm.) after 24 hours Growth at 25° C. Three Replicates of Five Coleoptiles each throughout

Date	Molar conc. of IAA	Agent	Molar concentration of agent 10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	Significant difference P 0·05	P 0·01
	0	Nil	1·64		1·63		1·64			
		NTA	**1·70**		**1·81**		**1·82**			
		IDA	**1·71**		**1·83**		**1·85**			
		AADA	**1·71**		**1·75**		**1·85**			
25.1.56									0·028	0·038
	10^{-5}	Nil	2·08		2·08		2·08			
		NTA	2·10		**2·16**		**2·23**			
		IDA	**2·12**		**2·15**		**2·18**			
		AADA	**2·11**		**2·17**		**2·20**			
	0	Nil	1·81		1·79		1·79			
		UDA	1·80		**1·85**		**1·89**			
		$\alpha\alpha$DP	1·80		1·80		**1·83**			
		$\gamma\gamma$DP	1·81		1·80		1·77			
11.2.56									0·028	0·037
	10^{-5}	Nil	2·02		2·02		2·03			
		UDA	2·04		**2·10**		**2·09**			
		$\alpha\alpha$DP	2·03		2·04		**2·06**			
		$\gamma\gamma$DP	2·00		2·00		**2·00**			
	0	Nil			1·91	1·91	1·90	1·90		
		$\alpha\alpha$DP			1·91	1·92	**1·94**	**1·94**		
		$\gamma\gamma$DP			**1·87**	**1·85**	**1·85**	**1·86**		
21.3.56									0·032	0·043
	10^{-5}	Nil			2·13	2·13	2·12	2·13		
		$\alpha\alpha$DP			2·12	2·14	**2·20**	**2·17**		
		$\gamma\gamma$DP			**2·09**	**2·06**	**2·03**	**2·03**		
	0	Nil	1·72	1·75	1·75	1·74				
		8HQ	**1·82**	**1·84**	**1·88**	**1·89**				
		2HQ	**1·75**	**1·71**	1·71	**1·73**				
19.2.56									0·029	0·039
	10^{-5}	Nil	2·06	2·06	2·08	2·07				
		8HQ	**2·10**	**2·10**	**2·15**	**2·12**				
		2HQ	2·08	2·07	2·06	2·06				
	0	Nil	1·84	1·85	1·84	1·85				
		DIECA	**1·89**	**1·97**	**1·92**	1·88				
		KCN	1·85	1·85	**1·74**	**1·73**				
1.2.56									0·031	0·041
	10^{-5}	Nil	1·98	1·98	1·98	1·98				
		DIECA	**2·05**	**2·04**	**2·09**	**2·05**				
		KCN	2·00	1·99	1·98	1·99				

Values in heavy type differ significantly from the corresponding control (nil). Key to agents: NTA = nitrilotriacetic acid; IDA = iodoacetic acid; AADA = anthranilic acid diacetic acid; UDA = uramildiacetic acid; $\alpha\alpha$DP = $\alpha\alpha$-dipyridyl; $\gamma\gamma$DP = $\gamma\gamma$-dipyridyl; 8HQ = 8-hydroxyquinoline; 2HQ = 2-hydroxyquinoline; DIECA = sodium diethyldithiocarbamate; KCN = potassium cyanide

except for 8HQ and DIECA, which both tended to cause less growth at 10^{-5} *M* than at 10^{-7} *M* in the presence of IAA but not in its absence.

At the suggestion of Dr. W. R. Rees, of this Institute, a similar experiment was carried out using 8HQ and its two analogues α-naphthol and quinoline. The chelating agent 8HQ increased growth as before, while the non-chelating analogues depressed growth in all concentrations used, whether with or without IAA.

It seemed clear that the various chelating agents must act as growth substances by virtue of their chelating properties, and this raised the possibility that IAA might act in the same way. We consulted Dr. E. R. Roberts, of the Chemistry Department, Imperial College of Science and Technology, who kindly informed us that in his view the distance between the imino and carboxyl groups of IAA was suitable for chelation to occur with the formation of a seven-membered ring. Such chelate compounds would be most stable with heavy metal ions such as Cu^{++} or Co^{+++}. Even if true chelates were not formed by IAA, complex formation would certainly be expected.

Nearly all the above preliminary experiments have since been repeated using a revised technique for setting up the coleoptile sections in the treatments, which gives consistently a standard deviation for one 'replication' (the mean of five coleoptile sections) of about 0·02 cm. or 1 per cent of the mean length after 24 hours. This has very greatly improved the precision of treatment comparisons, and therefore numerical results from these later experiments only are presented in Table 2.

All the chelating agents significantly increased growth, both in the absence and presence of IAA. In only one case did a non-chelating analogue (just) significantly increase growth (2HQ at 10^{-9} *M* without IAA), and here the corresponding 'control' value was an unusually low one, being 'significantly' less than two other 'controls'; this may well have been a fortuitous difference, therefore. In a number of cases the non-chelating analogues actually depressed growth, and this was again also true of potassium cyanide. It is not proposed to discuss the interactions with IAA at this juncture.

Before carrying out the experiments recorded in Table 2, it had seemed necessary to test the possibility that all the observed effects of chelating agents in our experiments (including perhaps even those of IAA) might be due to their removing harmful metal ions from the distilled water used. Distilled water from our usual source (a tinned boiler and 'Pyrex' glass condenser) was compared with water of very low ion content from a 'Biodeminrolit' mixed-bed ion-exchange resin column. Differences in growth between sections in the two samples of water were extremely small and entirely non-significant whether in the absence or presence of IAA and EDTA (10^{-5} *M*) alone or together. In this rather precise experiment a highly significant ($P < 0·001$) interaction of IAA and EDTA was found such that the combined stimulating effect was less than the sum of the effects of the agents acting separately (Table 3).

Table 3. Mean Length (cm.) of Wheat Coleoptile Sections, originally 1 cm., after 24 hours Growth at 25° C. Five Replicates, each of Five Coleoptiles (18.1.56)

	EDTA:	0 *M*	10^{-5} *M*
IAA	0 *M*	1·84	2·09
	10^{-5} *M*	2·11	2·24

Significant difference (P 0·05) = 0·02; (P 0·001) = 0·03

On the hypothesis that the two agents were acting in exactly the same way, an interaction in this sense would be expected if response tended to be linear with log concentration rather than with concentration itself. It should be noted, however, that the response to EDTA alone was just significantly less than that to IAA alone, although the difference in response was only 8 per cent.

Further experiments were designed explicitly to test the hypothesis that EDTA and IAA were identical in their action. The first two of these, with mixtures of the two agents in proportions 0 : 100, 25 : 75, 50 : 50, 75 : 25 and 100 : 0, at total concentrations of 10^{-7}, 10^{-6}, 10^{-5}, 10^{-4} *M* and 10^{-8}, 10^{-7}, 10^{-6} *M* respectively, showed in all cases somewhat more growth after 24 hours with the higher proportions of IAA. It seemed possible that this might be due to slower penetration of the EDTA into the tissues, and in two further experiments growth-time studies were made. In these, mixtures in the proportions 0 : 100, 50 : 50 and 100 : 0 at a total concentration of 10^{-6} *M* were used; fresh samples of coleoptile sections were measured at 3, 6, 12, 24 and 48 (or 36) hours. At 48 hours, in the first of these experiments, signs of morbid changes were observed; the results of the second experiment, therefore, are presented in Fig. 1.

It will be seen that the curve for pure EDTA rose more slowly than that for pure IAA, consistent with the hypothesis of slower penetration, but that by 36 hours the total growth was almost exactly the same. The significance of the interaction between the two agents can be tested by that of the quadratic coefficient in the regression of length on proportion of IAA; a coefficient not significantly different from zero is consistent with identical internal action of the two agents and a linear (or additive) response to amount penetrated. This coefficient varies very significantly with time, and most interest is attached to the interaction at 36 hours when penetration by both agents was probably almost complete. Here the combined effect in the 50 : 50 mixture was to give less total growth ($P < 0{\cdot}001$) than in either of the pure solutions, thus disproving the hypothesis of identical internal action of the two agents. On the other occasions, the effects were apparently additive at 3, 12 and 24 hours; but at 6 hours the combined agents again gave less growth than the mean of that in the two pure solutions.

It should be noted that for every chelating agent tried the greatest coleoptile extension obtained at 24 hours with the agent alone was significantly less than with 10^{-5} *M* IAA alone (Table 2). In some cases, at least, this might well be due to slower penetration, as with EDTA.

The results so far discussed are all for coleoptile growth; but three experiments on root growth have been carried out, in which intact wheat seedlings were grown in solutions of EDTA and IAA alone and combined. The results for the second and third of these experiments are presented in Tables 4 and 5. The solutions were made up in distilled water, without nutrients, and changed every 3 days. After 8 or 9 days growth the total length of roots on each plant and its longest root were measured. The

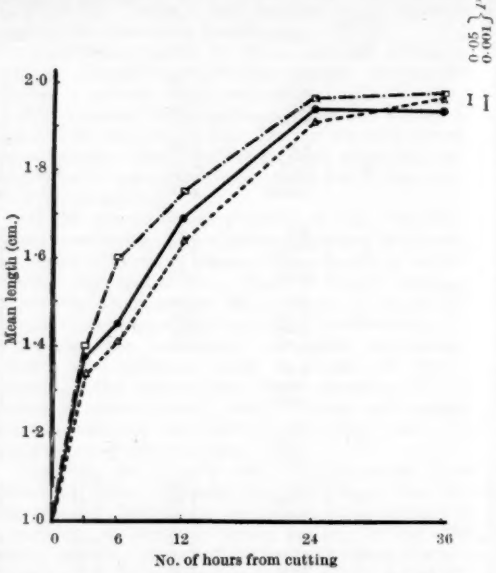

Fig. 1. ●—, 50 : 50 EDTA, IAA; □—·—, IAA only (10^{-6} *M*); △– – –, IAA only (10^{-4} *M*)

treatment means for total length only are presented, as the longest root data showed very similar effects.

IAA or EDTA alone show essentially similar effects; in fact, the two agents give almost the same results throughout the experiments. There is, however, evidence of a most remarkable mutual antagonism; thus the inhibitory effect of a 10^{-5} *M* concentration of *either* agent is completely or almost completely removed by the presence of a 10^{-9} or 10^{-11} *M* concentration of the other (that is, at one-hundred-thousandth or one-millionth the concentration). The underlying mechanism of this extraordinary mutual antagonism is obscure, and it is not proposed to speculate about it here. Clearly, however, although the main conclusions would be unaltered by interchanging the names IAA and EDTA in the tables, the mode of operation of the two agents cannot be identical, for adding 10^{-11} *M* IAA to 10^{-5} *M* IAA could scarcely prevent inhibition. It must be remembered that in coleoptile growth we have

Table 4. Total Length of Roots (cm. per plant) of Wheat Seedlings after eight days Growth. Two Replicates, each of Three Plants (23.3.56)

	EDTA:	0 *M*	10^{-11} *M*	10^{-9} *M*	10^{-7} *M*	10^{-5} *M*
IAA	0 *M*	*25·1*	*25·6*	*24·9*	*24·3*	12·5
	10^{-11} *M*	*26·1*	*27·3*	*24·6*	*25·8*	*24·1*
	10^{-9} *M*	*22·5*	*26·4*	*23·0*	*22·6*	*25·2*
	10^{-7} *M*	13·2	*24·4*	21·5	15·0	13·5
	10^{-5} *M*	12·1	*23·5*	20·4	12·7	10·9

Significant difference (P 0·05) = 2·64; (P 0·001) = 4·79
Values in *italics* do not differ significantly from that for water alone

Table 5. Total Length of Roots (cm. per plant) of Wheat Seedlings after nine days Growth. Two Replicates, each of Three Plants (21.4.56)

	EDTA:	0 *M*	10^{-11} *M*	10^{-9} *M*	10^{-7} *M*	10^{-5} *M*
IAA	0 *M*	*24·9*	*26·0*	21·0	16·3	8·9
	10^{-11} *M*	*25·8*	*26·3*	*24·2*	22·5	22·5
	10^{-9} *M*	*24·7*	*25·2*	*24·8*	22·0	21·3
	10^{-7} *M*	16·8	21·6	*22·8*	20·2	15·4
	10^{-5} *M*	6·5	*23·8*	*23·0*	16·1	11·3

Significant difference (P 0·05) = 2·39; (P 0·001) = 4·32
Values in *italics* do not differ significantly from that for water alone

been concerned with stimulation, but that here inhibition is the main effect; the slight stimulation at 10^{-11} *M* fails to reach significance even for the two agents together. It seems likely that the pathways of stimulation and inhibition may be entirely different, and thus quite different types of interaction between IAA and EDTA for coleoptile and root growth might be expected. Experiments on inhibition of coleoptile growth by supraoptimal concentrations would be of interest and it is hoped to undertake these shortly.

The first root-growth experiment, with a different variety of wheat, showed a similar type of mutual antagonism between EDTA and IAA, but here a concentration of 10^{-7} *M* of one agent was needed to remove the inhibition due to a 10^{-5} *M* concentration of the other.

During the course of this investigation, between the carrying out of the preliminary experiments and those with the revised technique, Prof. T. A. Bennet-Clark very kindly showed us the proof of his paper at the Wye Growth Substance Conference[2], in which he reports the finding that EDTA in concentrations from 10^{-5} *M* to 10^{-3} *M* can act as a growth promoter in the straight-growth test and suggests that the calcium metabolism of the cell wall is concerned.

All the biological evidence presented here would seem consistent with the hypothesis that IAA acts on growth in the same way as a chelating agent, either by forming true chelate compounds or complexes of some sort, although its mode of operation cannot be *identical* with that of EDTA in view of the peculiar interactions which occur between the two; as yet, however, we have obtained no experimental chemical evidence of such complex formation by IAA. If it in fact acts as a growth substance by virtue of complex-forming properties, there would seem to be three ways in which it might do so: first, it might act by removing metal ions which would otherwise restrict growth, as in the suggested effect of EDTA in removing calcium from pectate in the cell wall[2], though chelation of heavy metals would seem more probable; secondly, it might act as an enzyme inhibitor, either by removing metals needed as coenzymes or perhaps by 'covering up' metals in prosthetic groups. In this connexion it may be noted that Smith, Lumry and Polglase, cited by Martell and Calvin[3], found that IAA strongly inhibited the Mg-stimulated enzyme carboxypeptidase. Thirdly, work by Calvin[4] and Weller and Mills[5] has shown that a complex of an acetate and two quinoline molecules with copper can transfer hydrogen and thus function as a catalyst for the hydrogenation of suitable hydrogen acceptors—IAA might form complexes which could function in a similar manner. It will be noted that in the first two suggestions IAA would be inhibiting some aspect of metabolism; in the third, it would be itself contributing positively to metabolism. If IAA could function in two or all three of these ways, its extraordinary range of known effects on growth and development would be less surprising.

Synthetic auxins in general may also act through their complex-forming activities. Thus, for example, 2-4-dichlorophenoxyacetic acid is, in Dr. E. R. Roberts's opinion, more likely to form metal complexes than phenoxyacetic acid (which is inactive[6]). This would explain the very wide variety of compounds which are found active, including in the present work many which do not conform to the structural pattern generally postulated for auxins (for example, by Thimann[6]), and would also account for their similar but wide range of effects.

Further work, including experiments with various metallic ions, is in progress, and detailed publication will follow in due course.

We are grateful to Drs. W. R. Rees and J. Edelman, of this Institute, for helpful suggestions and discussions, in particular to the former for suggesting the experiments with analogues of 8-hydroxyquinoline; also to Dr. E. R. Roberts, of the Chemistry Department, Imperial College, for providing the theoretical evidence that indolylacetic acid is likely to act as a chelating or complex-forming agent.

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AN UNORTHODOX VIEW OF THE WEATHER

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FOR more than a generation the concept of the general circulation of the atmosphere has played a dominant part in the science of meteorology. It has helped explain many of the mysteries of weather phenomena and been responsible for great advances in this field of endeavour. The working tool of the forecasting meteorologist is the synoptic chart, which shows the pressure distribution over the surface of the Earth at any given time. Being based on measurements of barometric pressure at many points on the Earth's surface, the chart represents a very real physical situation. It gives vital information on the movement of air masses and has become the most important aid to forecasting the weather. It is especially useful for aircraft, which have the problem of moving around within those air masses. But it has its weaknesses, particularly on the question which is of most interest to the man in the street, namely, the forecast of whether it will rain to-morrow.

The method of preparing a forecast of rain from the chart has been variously described as 'a matter of intuition' or 'an empirical process which draws on past experience'. How is it that intuition and empiricism come into this important function and how can they be taken out? The forecaster has available to him a large number of physical measurements collected from a wide network of observing stations. Some of these, like the instability of the

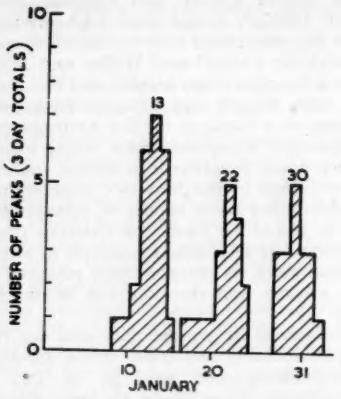

Fig. 1. Histogram of the dates in January on which the concentration of freezing nuclei was observed to be high in the three years 1954, 1955 and 1956

atmosphere and the amount of moisture aloft, are closely related to whether clouds will form. But a measurement which has a direct physical connexion with the formation of rain is lacking.

It has been known for some time that such a measurement is possible; but its importance has not been fully appreciated. In the study of cloud physics, it is well established that the number and properties of the freezing nuclei present in the atmosphere determine whether rain will form in a supercooled cloud. Freezing nuclei, in this context, may be defined as particles on which ice crystals can grow from the vapour phase, or else materials which in solution in a water droplet or in contact with it will induce it to freeze. Measurement of the concentration of freezing nuclei and the temperature at which they become active is not easy; but if such measurements are made in aircraft or at sites which are free from the interfering effects of dust from terrestrial or industrial sources, several interesting facts emerge. It is found, for example, that while measurements of the concentration of freezing nuclei are consistent among themselves in one area or over a few hours at a time, changes of several hundred to one are possible from one day to the next. Many of the quantities used in meteorology, such as barometric pressure, vary at most by a few per cent and can only be linked with the formation of rain by what is admitted to be a subjective process. By contrast, the number of freezing nuclei in the atmosphere has a direct bearing on the formation of rain. It may vary by orders of magnitude from one day to the next; but the unfortunate forecaster is unaware that such a change has taken place. Could this be the reason why forecasts of rain sometimes go wrong? Could a sudden and unobserved increase in freezing nucleus concentration lead to the development of rain which did not appear likely from the synoptic chart?

Table 1. Dates of High Counts of Freezing Nuclei in January 1954–56

Year	Place	Date (January)		
1954	Sydney	12 14	22	31
1955	Sydney	13	23	29
	Hawaii	10	23	29
	Arizona	—	—	—
	Panama	13	18	31
1956	South Africa	13	—	29
	West Australia	13	22	Feb. 1
	Sydney	—	—	—
	San Francisco	13	21	—

For a proper assessment of the role of freezing nuclei, measurements are needed in many parts of the world. These are just beginning to be made on a routine basis, and they already point to a further intriguing possibility—that the sudden changes occur at almost identical times in different parts of the world. Smith, Kassander and Twomey[1] have reported measurements made in Sydney in January 1954 and again in Sydney, the Hawaiian Islands and Panama in January 1955, which showed there were sudden increases in the number of freezing nuclei on the dates given in the first part of Table 1. Similar measurements made in Arizona showed no significant variations. In January 1956 there were no increases in Sydney comparable in magnitude with those of previous years; but measurements in South Africa, Western Australia and the west coast of the United States showed marked increases on the dates shown in the latter part of Table 1. I am indebted to Dr. S. C. Mossop, of the National Physical Laboratory, Pretoria, Dr. E. K. Bigg, of the Radiophysics Laboratory, and Dr. R. N. Bracewell, of Stanford University, for permission to quote these results. The peaks do not always appear in all localities; but when they do occur, they are nearly simultaneous in widely separated parts of the globe. Furthermore, they seem to recur on approximately the same dates from year to year. A histogram giving the dates on which the freezing nucleus counts were high is given in Fig. 1, indicating that for the three years 1954,

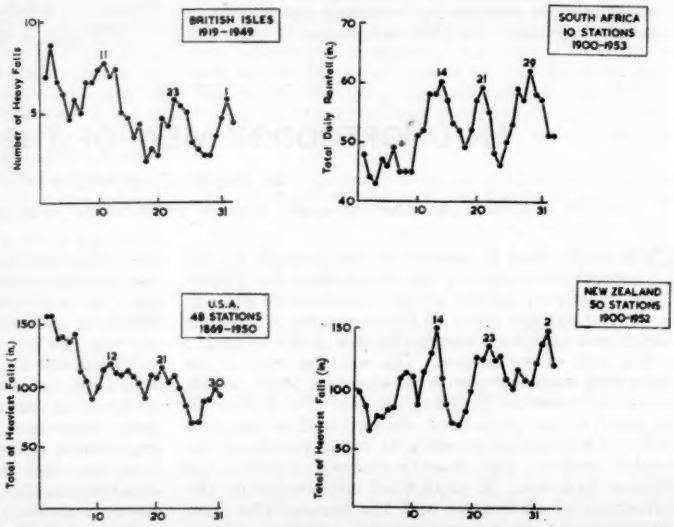

Fig. 2. The January rainfall of four countries in widely separated parts of the world

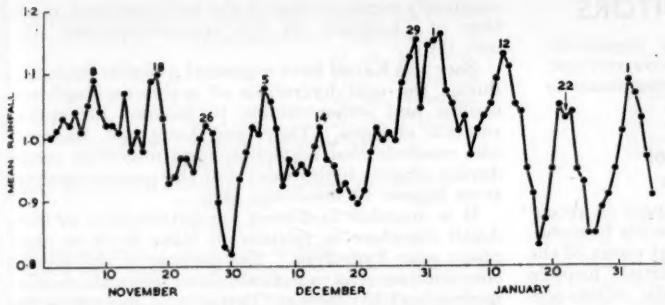

Fig. 3. The mean rainfall of November, December and January for three hundred stations distributed over the globe

1955 and 1956 the maxima occurred on January 13, 22 and 30.

This behaviour is strikingly similar to that of the rainfall in many parts of the world. As reported in a recent publication[2], if the records of a large number of stations are examined, there appears to be a preference for heavy falls of rain to occur on certain dates. In Fig. 2 is given the number of falls of rain exceeding $2\frac{1}{2}$ in. in 24 hours in January in the rain-gauge network of Great Britain for the period 1919–49. It shows distinct variations from one day to the next. In the remaining curves are corresponding observations for three other regions of the globe, namely, forty-eight stations in the United States, ten in South Africa and fifty in New Zealand. In each case the stations were chosen by officers of the respective weather bureaux to be representative of the whole country. There appears to be a remarkable agreement between them, in spite of the widely different climatic regimes which exist in these areas, and the fact that they refer to winter-time in one hemisphere and summer-time in the other. There are three rainfall peaks which appear within a few days of each other on all four curves and, furthermore, they are grouped around the dates January 13, 22 and 30, on which the concentration of freezing nuclei in the atmosphere has been observed to have high values.

The close relationship between the January rainfall of widely separated regions which is exhibited in Fig. 2 is not in accord with conventional meteorological ideas. As it is so difficult to explain the present effect on ordinary climatological grounds, let us look outside the immediate boundaries of meteorology for the explanation. The clues are clear-cut—the effect appears to be one which occurs almost simultaneously over the globe, which suggests an extra-terrestrial phenomenon; and it takes place on particular calendar dates, which suggests an association with meteor showers.

Table 2. Comparison of Dates of Meteor Streams and Rainfall Peaks

Date of rainfall peak	Meteor stream	Date	Time difference (days)
Nov. 8	Giacobinids	Oct. 9	30
18	Orionids	Oct. 20–23	29
26	Not known with certainty		—
Dec. 5	Taurids	Nov. 3–10	32
14	Leonids	Nov. 16	28
29	Bielids I	Nov. 27→15	—
Jan. 1	Bielids II	Dec. 2	30
12	Geminids	Dec. 13	30
22	Ursids	Dec. 22	31
Feb. 1	Quadrantids	Jan. 3	29

Relation to meteor showers. The Earth in its orbit is known to pass through streams of dust which exist in vast elliptical orbits around the Sun. The dust includes a wide range of particle sizes. The large ones burn up on entering the atmosphere and appear as visible meteors; the smaller particles do not have enough energy to be consumed and fall slowly into the lower atmosphere. Svestka[3] has shown that meteoritic dust takes between thirty and forty days to fall from the top of the atmosphere to the troposphere. It may be significant that there are three prominent meteor showers about thirty days before the rainfall peaks, namely, the Geminids of December 13, the Ursids of December 22 and the Quadrantids of January 3.

It appears, therefore, that the rainfall peaks might occur about a month after the meteor showers. This possibility can be tested in an elementary way by examining the rainfall of a somewhat longer period than that given in Fig. 2. In Fig. 3 is a curve of the mean rainfall for the three months November, December and January for a period of about sixty years. The curve is for approximately three hundred stations distributed over the globe, and includes those already referred to in the United States, Great Britain, South Africa and New Zealand, together with fifty stations from Australia, thirty-two from Japan and five from the Netherlands. The dates of ten of the most prominent peaks are listed in the first column of Table 2, together with a list of the meteor showers which appear to correspond. The only rainfall peak which is not associated with a well-known meteor shower is that of November 26; nevertheless, Ellyett and Roth[4] have reported previously unsuspected meteor activity in the southern hemisphere approximately a month before this date. In the interests of brevity, the results in this table are only given in the barest outline, and a full treatment is in course of publication in the meteorological literature.

In the final column of Table 2 is the difference in time between the meteor showers and rainfall peaks, and it is seen to have a mean value of 30 days, with greatest departures from this value of $\pm$ 2 days. The hypothesis has therefore been advanced that dust from meteor streams falls into the cloud systems of the lower atmosphere, nucleates them and causes exceptionally heavy falls of rain thirty days after the dust first entered the atmosphere.

There are several aspects of this hypothesis which are difficult to accept, and many questions arise. Why should meteoritic dust be so active as a nucleating agent? Why does the time of fall appear to be so consistent from one shower to the next? And why is the effect on rainfall confined to such a few days? As yet these are without answer; but there is already enough evidence about the reality of the effect to call for a thorough investigation of the physics of the phenomenon and a careful assessment of its impact on the day-to-day problems of meteorology.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Hydrolysis of Esters of Monoribonucleotides

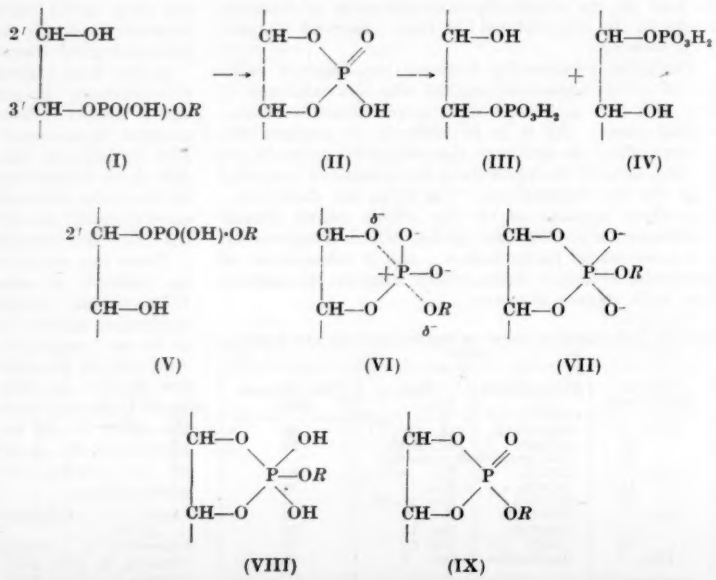
Considerable attention has been paid in recent years to the hydrolysis of ribonucleic acids to mononucleotides. It was shown[1,2] that alkyl esters of the 2′- and 3′-monoribonucleotides (partial formula I ; R = alkyl) provided simple model substances which could be used for a more precise study of the mechanism of hydrolysis. The overall process, effected by acid or by alkali, results in a conversion of (I) to a mixture of (III) and (IV). Both procedures involve the unstable cyclic ester intermediate (II), which is then hydrolysed to the isomeric mononucleotides (III) and (V). Since the conversion of (I) → (II) is formally a trans-esterification[3], it seemed possible that the analogous process (I) → (V), that is, migration of the alkyl phosphate residue without loss of R, might also occur simultaneously.

When cytidine-3′ benzyl phosphate (I ; R = $CH_2.C_6H_5$) is partially hydrolysed by 0·5 N sodium hydroxide solution, the ester recovered can be shown by ion-exchange chromatography to contain none of the corresponding 2′-ester (V). Other experiments show that no observable conversion of a 2′-methyl ester (V ; R = Me) to the 3′-ester (I) occurs under similar conditions. Thus under alkaline hydrolytic conditions, no migration of the alkyl phosphate group occurs. This result appears to imply that the step (I) → (II) involves a transition state which may be represented by (VI), and not a discrete molecule such as (VII) analogous to that involved in the alkaline hydrolysis of carboxylic esters[4].

After partial acid hydrolysis, however, analysis of the remaining ester reveals that migration of the alkyl phosphate group occurs to a significant extent. Thus when hydrolysis of (I ; R = CH_2Ph) is carried to 53 per cent of completion, (V) accounts for 25 per cent of the remaining ester. Of direct significance for ribonucleic acid chemistry is the finding that the dinucleoside phosphate adenosine-2′ uridine-5 phosphate[5] (V ; R = uridine-5′ residue) yields a proportion of the rearranged product adenosine-3′ uridine-5′ phosphate. Qualitative observations on the rate of hydrolysis indicate that the reaction is catalysed by acid. The results are accommodated if protonated species derived from intermediates of type (VIII) or (IX) are postulated, the latter arising directly or *via* (VIII). These could then lead by P—O fission either to (I), (II) or rearranged ester (V). The mechanism of the rearrangement (I) → (V) is presumably essentially similar to that of the acid-catalysed migration of phosphate in the mononucleotides (III) and (IV).

Baer and Kates[6] have suggested a similar migration during the acid hydrolysis of α-glycerophosphorylcholine and -ethanolamine to account for optical rotation changes. They, and Long and Maguire[7], also conclude that alkylphosphoryl migration occurs during alkaline hydrolysis ; but the present observations appear to invalidate this.

It is intended to discuss our experiments in more detail elsewhere in relation to other work on phosphate ester hydrolysis. The purpose of the present communication is to indicate their relevance to ribonucleic acid hydrolysis. Partial acid hydrolysis has been used for preparing a variety of oligonucleotides[8]. The internucleotidic linkage in ribonucleic acids is at present considered to involve a phosphodiester bridge exclusively between the 3′- and 5′-positions in adjacent ribonucleoside residues[9]. On the above evidence, however, partial acid hydrolysis of such a structure must be expected to give rise to oligonucleotides, a proportion of which will have a 2′ : 5′-internucleotidic linkage. The isolation of such a substance will, in itself, afford no evidence for a 2′ : 5′-linkage in the ribonucleic acid structure. Furthermore, present enzymic methods for polynucleotide structure analysis, if applied without realization of the possibility of isomerization of the internucleotidic linkage, may lead to erroneous conclusions. This follows from the fact that the nuclease-type enzymes (for example, ribonuclease) have differing specificities for purine and pyrimidine nucleoside sites in the molecule, but all those studied have shown a specific requirement for a 3′ : 5′-internucleotidic linkage[9]. The validity of the use of such nucleases for sequence determination in oligonucleotides rests on the assumption that the 3′ : 5′-internucleotide linkage is preserved unchanged during the hydrolysis of the nucleic acid ; it loses its validity if a change from 3′ : 5′- to 2′ : 5′- can occur. Such methods should be supplemented by the known



chemical degradation, which can distinguish between a 3′ : 5′- and 2′ : 5′-phosphodiester linkage[10].

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Ionophoresis of Oligosaccharides as N-Benzylglycosylammonium Ions

Filter-paper ionophoresis is now being widely used for separations of mixtures of neutral sugars, which are converted into charged molecules by the formation of borate complexes[1]. This excellent method provides a far more rapid separation of isomeric components which possess appropriate structural differences than does filter-paper chromatography; and at the same time, deductions can be made about the probable structure of an unknown sugar from its rate of migration. It does, however, suffer from a disadvantage when compared with filter-paper chromatography, inasmuch as it does not give any indication of the molecular size of an unknown oligosaccharide. We now report a different method of filter-paper ionophoresis which readily yields this information; it is to be regarded as complementary to the borate process. When both methods are used in conjunction, much information about a new product can be gained very rapidly.

This alternative method of ionophoresis is a development of the technique of filter-paper chromatography in which reducing sugars are converted on the paper into N-benzylglycosylamines[2]; in this case a charge is afterwards placed on the nitrogenous derivative by using a strongly acid solution as the medium during electrolysis. In the general method the reducing sugar is spotted on to a strip of Whatman No. 3 filter-paper, and a spot of a solution of benzylamine (1 c.c.) in methanol (9 c.c.) and 10 *N* formic acid (5 c.c.) is superimposed. The paper is heated at 95° for 5 min. and then subjected to ionophoresis at 600 V./55 cm. for 6 hr. in an electrolyte (*p*H 1·8) composed of a mixture of 5 per cent aqueous sodium hydroxide (600 c.c.) and 90 per cent formic acid (400 c.c.). The paper is dried to remove all formic acid, and the spots are detected with alkaline silver nitrate[3] or periodate[4]. The mobility is expressed as the ratio between the distance which separates the N-benzylglycosylammonium ion from the unchanged sugar and the distance which separates the N-benzylglucosylammonium ion from unchanged glucose. It is quite convenient to measure these distances because the reaction between the sugar and the benzylamine is not complete (cf. ref. 2). Typical results are given in Table 1.

Table 1

Sugar	Mobility*
Pentose	1·09–1·15
Hexose	1·00
Heptose	0·91
Hexose disaccharide	0·71–0·78
Hexose trisaccharide	0·59–0·63
Hexose tetrasaccharide	0·49–0·51
Hexose pentasaccharide	0·42
Hexose hexasaccharide	0·33

* Defined in text.

It will be seen that the mobility bears an inverse relationship to the molecular weight of the ion; to the first approximation, it is independent of the stereochemistry of the sugar and also of the positions of the linkages in a higher saccharide. Full details of this work, including the experiments which led to the development of the general method and studies with amines other than benzylamine, will be reported later. The work was supported by a grant from the Nuffield Foundation.

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Ion-Exchange Preparation of Low-Silica Hydroxide Solutions for Colorimetric Determinations of Total Silica

Attempts to determine small concentrations of total silica colorimetrically by applying the method of Straub and Grabowski[1], following solubilization of the silica by boiling with hydroxide, have been frustrated by the interference of the silica present in either the sodium or potassium hydroxide used as the solubilizing agent. In studying this problem, the possibility of preparing a hydroxide solution by passing a salt solution through the hydroxide-form of a quaternary-base ion-exchange resin was investigated. The fact that complete conversion from the salt to the hydroxide is not required for the analytical method is a recommendation of this approach; a salt solution more concentrated than is normally amenable to ion-exchange treatment may be used as the starting material in order to produce a moderately concentrated hydroxide solution.

A quaternary ammonium-type anion-exchange resin ('Amberlite *IRA*-400') was used in the preparation of the caustic solutions. A small column of the resin was prepared in a 1- or 2-in. diameter polyethylene pipe. The resin was converted to the hydroxide-form by treating it with six volumes/volume resin of 4 per cent sodium bicarbonate solution followed by six volumes/volume resin of 4 per

cent sodium hydroxide solution both at a rate of 0·15 ml./ml. of resin/min. The column of resin was then rinsed to a *p*H of 9·5 with deionized water.

Solutions of *N* potassium chloride and of *N* potassium sulphate have been used as starting materials for the preparation of caustic solutions. The potassium salts were selected in preference to the corresponding sodium salts because they contained smaller amounts of silica. The salt solutions were passed through the resin at the rate of 0·15 volume/volume resin/min. A total of one volume of salt solution per volume of resin was treated in each cycle. Regeneration of the column between cycles was carried out with sodium bicarbonate and sodium hydroxide by the same method as the original regeneration. In each cycle the hydroxide effluent was collected in five equal fractions and analysed for silica content and for their hydroxide content. Typical results are given in Table 1.

Table 1. Characteristics of Hydroxide Solutions prepared via Ion Exchange

Cycle	1	2	3	4
Column size	2 in.*	2 in.†	2 in.	2 in.
Influent	1 *N* pot. chloride	1 *N* pot. chloride	1 *N* pot. sulphate	1 *N* pot. sulphate
N Hydroxide				
Cut 1	—	0·369	—	0·413
Cut 2	—	0·501	—	0·505
Cut 3	0·106	0·501	—	0·455
Cut 4	0·311	0·437	—	0·405
Cut 5	0·451	0·379	—	0·343
p.p.m. Silica				
Cut 1	5	—	0·78	0·20
Cut 2	5	2·2	0·67	0·12
Cut 3	5	2·0	0·31	0·11
Cut 4	5	—	0·29	0·10
Cut 5	5	—	0·24	0·10

* Glass column.
† Only sodium hydroxide used as regenerant.

It may be seen that the quality of the effluent hydroxide increases with increasing number of regeneration cycles. The solution prepared in cycle 4, when used for solubilizing silica at a ratio of 1 ml./50 ml. of water sample, contributes only 0·002 p.p.m. to the final solution being analysed. This is below the present limits of detection of silica by colorimetric methods.

The above procedure is now being employed in a study of the concentration of soluble and total silica in ion-exchange resin deionization systems, and the results of this study will be submitted for publication in the near future.

Sallie Fisher
Robert Kunin

Rohm and Haas Co.,
Philadelphia, Penn. Jan. 11.

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Use of the Orcinol - Sulphuric Acid Reaction in the Positive Identification of Certain Monosaccharides from a Salivary Mucoid

An approximate identification of sugars separated from hydrolysates of biological material can usually be made by paper chromatography. Positive identification is usually achieved by the measurement of some specific physical property such as optical rotation, or the preparation of derivatives possessing characteristic melting points. It frequently happens that sugars separated from hydrolysates are present in insufficient amounts to enable such methods of identification to be used.

The modified orcinol – sulphuric acid reaction described by Bruckner[1] is eminently suitable for the identification of small amounts of various hexoses, which give characteristic absorption spectra readily distinguishable from one another. The different aldopentoses exhibit the same absorption curve which, however, is different from those of the individual hexoses. As little as 0·1 mgm. of the sugar is necessary to obtain a satisfactory absorption curve.

In the course of our investigations into the composition of mucoids occurring in human saliva, a fraction was obtained which was thought to be identical with the 'blood group A substance' described by Aminoff, Morgan and Watkins[2]. Less than 100 mgm. of the substance was hydrolysed by refluxing with water in the presence of 1 gm. of 'Amberlite *IR*120' ion-exchange resin at 100° C. for 16 hr. The resin was filtered off and washed with water. The combined filtrate and washings were evaporated to dryness *in vacuo* and the residue taken up in 2 ml. of water.

One-dimensional chromatograms were run on Whatman No. 1 paper in methyl ethyl ketone/acetic acid/water (6 : 1 : 1), a very rapidly running solvent introduced in this laboratory (Leaver, A. G., and Irwin, M., unpublished work). Two of these gave R_F values approximating to those found for galactose and fucose. When the hydrolysate was again run with spots of these two sugars run adjacently, the tentative identification was confirmed.

The total hydrolysate was applied to three wider strips of the very thick paper Whatman No. 3 *MM*, application being in the 'ribbon' form across the width of each paper. Development was continued for 18 hr., after which the chromatograms were dried, narrow strips cut from each edge and sprayed with aniline hydrogen phthalate. The areas corresponding to the two principal bands obtained were cut out of the main strips and eluted with distilled water. The two eluates were evaporated to dryness *in vacuo*, the solids being weighed and taken up in distilled water to give a concentration of 0·1 mgm. per ml. Both solutions were then treated with orcinol and sulphuric acid, according to the method of Bruckner[1], absorption curves being measured on the 'Unicam' S.P.600 spectrophotometer. The first solution gave the typical absorption curve for galactose, whereas the latter exhibited the highly characteristic spectrum of fucose, which shows maxima at 390 mμ and 500 mμ and is totally different from all other spectra examined (Bruckner, private communication).

Thus galactose and fucose were identified as neutral sugars present in the hydrolysate of the salivary mucoid. It is of interest that Aminoff, Morgan and Watkins[2] found these two sugars in hydrolysates of human 'blood group A substance'.

Use of the orcinol – sulphuric acid reaction for the positive identification of monosaccharides affords a rapid and simple way of making definite confirmation of results obtained by paper chromatography.

We are indebted to Dr. J. Bruckner for his valuable assistance and for making available the unpublished absorption curve for fucose.

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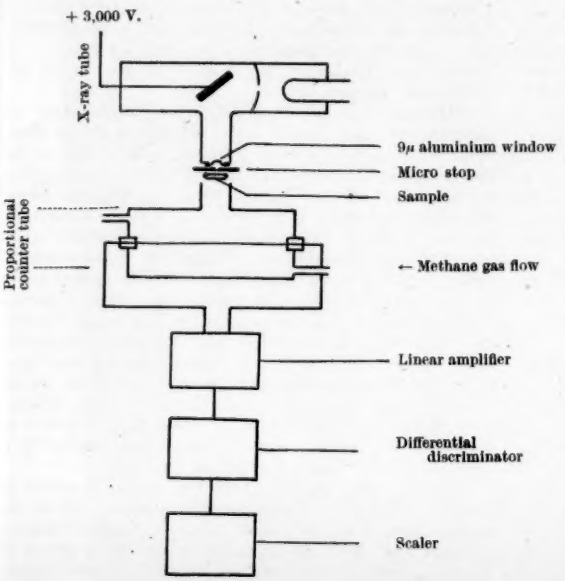
X-Ray Mass Determination in Cells by Scanning

In 1949–50 Engström and Lindström published a method for determining the cell mass by means of absorption measurements in soft X-radiation. In the wave-length range 6–12 A., the absorption of the X-radiation is proportional to the mass of carbon, nitrogen and oxygen substances. The cells are photographed together with a reference system in which the absorption – wave-length relationship is the same. The photographic emulsion and process are the main limit to accuracy and resolving power.

The photographic process can be evaded by scanning the section of the cell with a very thin pencil of X-rays, and then measuring the transmission direct. The possibilities of obtaining a measurable amount of X-radiation through a small stop of 1·8μ has first been examined. The wave-lengths must be within the limits 6–12 A., and to prevent getting too great a geometrical unsharpness the pencil of rays must be almost parallel.

A sealed-off X-ray tube has been constructed which has a thin window through which the rays pass. The window is of aluminium foil 9μ thick, which at the same time serves as a filter. The diameter of the focus is 1·5 mm. and the focus-window distance is 70 mm. The anode voltage is 3 kV. and the anode current 1 m.amp. A gold micro-stop is placed immediately in front of the window. The rays pass through the stop and enter a windowless proportional counter through which methane is flowing.

The possibility of obtaining measurable quantities of rays through the micro-stop is a problem of intensity; but it is further complicated by the natural radiation giving a background, the irregular variations of which can be expected to be greater than the radiation passing through the micro-stop. This problem has been solved in the following way. The height of impulses from the proportional tube depends on the energy of the radiation. The soft, low-energy radiation which is used here gives very much smaller impulses than the high-energy natural radiation. The high impulses are blocked in a differential discriminator, and only impulses below a certain height reach the impulse counter. Consequently, the disturbing background becomes insignificant. By using this form of X-ray tube and these conditions of operation (Fig. 1), a micro-stop with a diameter of 1·8μ resulted in a mean of 145 impulses/min. being obtained; the background was found to be 15 impulses/min. Quite measurable quantities were thus passing the stop.



Proportional tubes in connexion with the differential discriminator, however, give still another possibility. Impulses below a certain level can also be excluded, and thus only impulses between two levels will be counted. If these levels are set close to each other, it will be possible to measure within a very narrow range of wave-lengths. This means that absorption measurements in cells of various substances can be carried out at their maximum absorption. Further quantitative examination of the chemical components in the cells should thus be possible.

Preliminary investigations have shown that mass determination in cells is possible by scanning with X-rays. Further investigations will be published later on.

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Some New Stereochemical Arrangements of Divalent Palladium and Platinum

The usual stereochemistry of divalent palladium and platinum is that of a square-planar arrangement, associated with $(n-1)dnsnp^2$ bonding. A number of structures of this type have been reported[1]. The stereochemistry of square complexes has been discussed in considerable detail by Mellor[2]. With the exception of a few compounds such as the pyrromethene[3] and triaminotrimethylamine[4] complexes, where the bonds must be forced out of a plane, the four bonds to a bivalent platinum atom are invariably planar.

A few compounds have been reported in which the divalent platinum atom has been said to be six-covalent. For example, *bis*-(acetonitrile) tetrammine platinous chloride, $[Pt(NH_3)_4(CH_3CN)_2]Cl_2$, has been prepared in what are claimed to be *cis*- and *trans*-forms[5]. An octahedral arrangement has also been suggested for the *bis*(α,β,γ-triaminopropane) platinous ion[6]. The evidence for the proposed octahedral arrangements is, however, purely chemical.

While investigating recently the complexes of the chelate group *o*-phenylene*bis*(dimethylarsine) (denoted by diarsine) the reaction

$$[M(\text{diarsine})_2]^{++} + X^- \rightarrow [M(\text{diarsine})_2X]^+$$

where X = Cl, Br and I, and M = Pd and Ni, was observed to occur in non-aqueous ionizing solvents such as nitrobenzene, and complexes of the general formula $[M(\text{diarsine})_2X]^+ClO_4^-$ (M = Pd and Ni) have been isolated from acetone solutions[7]. These metals apparently exist as five-covalent ions $[M(\text{diarsine})_2X]^+$ in nitrobenzene solution[7], for the perchlorates function as uni-univalent electrolytes in this solvent. It is to be expected that compounds

of the type $[M(\text{diarsine})_2X]^+ClO_4$ would involve a five-covalent metal ion in the solid state. Special interest is attached to the structure of the series $M(\text{diarsine})_2I_2$, where M = Ni^{II}, Pd^{II} and Pt^{II}. These iodides also behave as uni-univalent electrolytes in nitrobenzene solution, presumably forming the ions $[M(\text{diarsine})_2I]^+$ and I^-, bearing in mind that a molecule of the solvent may be co-ordinated to the cation, thus making the metal six-covalent. The structure of these di-iodides has now been investigated to determine if five- or six-covalency occurs in the solid state.

Single crystals, from nitrobenzene, of the above platinum and palladium compounds have been examined in detail using the Buerger precession camera and molybdenum $K\alpha_{1,2}$ radiation. Apart from small visual variations in spot intensities, the reciprocal lattice nets are identical. The space group is $P_{2_1/c}$ and the unit cell has the dimensions: a = 9·68 A.; b = 9·27 A.; c = 17·27 A.; β = 114° 30′. It contains two molecules, which must therefore be at centres of symmetry. A satisfactory trial model was obtained using $h0l$ and $0kl$ Patterson maps, and the isomorphous replacement method, using the nickel, platinum and palladium complexes, agreed with these results. The refinement of atomic co-ordinates has proceeded using successive $\{|F(\text{obs.})| - |F(\text{calc.})|\}$ difference syntheses computed along the a- and b-axes. The reliability indexes

$$R = \frac{\Sigma\{|F(\text{obs.})| - |F(\text{calc.})|\}}{\Sigma|F(\text{obs.})|}$$

at present have the values $R(h0l)$ = 0·13 and $R(0kl)$ = 0·14. These values of R include contributions from carbon atoms as well as the heavy palladium, arsenic and iodine atoms. The light carbon atoms showed up quite well despite the presence of the heavier metal and arsenic atoms.

The structure consists of discrete molecules of $M(\text{diarsine})_2I_2$. The central atom is surrounded by four arsenic atoms in a square plane and at distances of approximately 2·38 A. The two iodine atoms complete a distorted octahedral arrangement with elongated metal–iodine bonds of 3·52 A. The calculated Pd—I bond distance in square palladium complexes is only 2·65 A. These preliminary results are in complete accord with bond-lengths expected from the crystal (ligand) field theory. The palladium (II) atom in an octahedral $Pd(\text{diarsine})_2I_2$ molecule has eight non-bonding $4d$ electrons. Six of these form a symmetrical closed sub-shell of d_ε orbitals, whereas the remaining two are almost certainly in a $4d_{z^2}$ orbital. The vacant $4d_{(x^2-y^2)}$ orbital points in the direction of the four arsenic atoms and, together with a $5s$ and two $5p$ orbitals, forms four square $4d_{(x^2-y^2)}5s5p^2$ bonds. Pointing along the axis of the two Pd—I bonds is the filled $4d_{z^2}$ orbital, which must exert a strong repulsion upon the two iodine atoms, leading to a considerable increase in bond-lengths. The two iodine atoms might be conveniently regarded as bound by linear hybrid $5p5d$ bonds—an interpretation in accord with the length of the bonds, with ligand field-theory, and with their covalent character.

Compounds of the formula $[M(\text{diarsine})_2X]ClO_4$, where M = Pd, Ni, and X = I, Cl, also form an isomorphous series. The unit cells are body-centred tetragonal and have the dimensions a = 13·33 A.; c = 32·44 A. There are eight molecules per cell. The space group is probably I_{4_1}. Systematic absences occur when $h + k + l = 2n + 1$ and $001 \neq 4n$.

The structures of these compounds are at present being examined with the view of determining the presence or otherwise of an asymmetrical five-covalent ion in these non-centric cells. A more detailed account of these investigations will be reported in due course.

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Cation-Exchange Properties of Zirconium (IV) – Tungsten (VI) Precipitates

In an investigation of adsorptive properties of inorganic materials, precipitates of tungstate brought down by addition of zirconium (IV) solutions were found to have cation-exchange properties. The adsorbent may be prepared by mixing a solution of zirconium oxychloride with a large excess of sodium tungstate solution (adjusted to *p*H *c.* 1·2 with hydrochloric acid). The precipitate (mole ratio tungsten/zirconium of about 3/1) is dried at 25° without washing, ground and screened. The conditions of preparation are not critical, so long as the acidity is not too high. Drying the precipitates for 24 hr. at temperatures above 80° C. sharply decreases both uptake of cations and the values of distribution coefficients D (amount adsorbed per kgm. adsorber/amount per litre of solution); at 150° C. the exchange properties of the solid are essentially destroyed.

Although cations in general can apparently be adsorbed on and eluted from the materials in characteristic cation-exchange manner, most work so far has concerned the alkali metals. For these, adsorption is rapid and reversible. essential equilibrium being attained in a matter of minutes. Under some conditions, at least, the materials show essentially ideal ion-exchange behaviour. Thus, in adsorption of tracer cæsium from ammonium chloride solutions, a plot of log D versus log M ammonium chloride gave a straight line of slope minus one in the range studied (0·1–1 M ammonium chloride). Apparent capacities are relatively high (0·5 mole cæsium uptake per kgm. from 0·1 M cæsium chloride) and selectivities appear good. Thus, distribution coefficients D for cæsium and rubidium were 65 and 21 respectively, in 0·1 M ammonium chloride, and similarly large ratios of D were found for the other alkali metals.

These results suggested that the materials could be used for separations with small columns. As an example, separation of the elements sodium to cæsium on material dried at room temperature is given in Fig. 1; conditions are summarized in the figure.

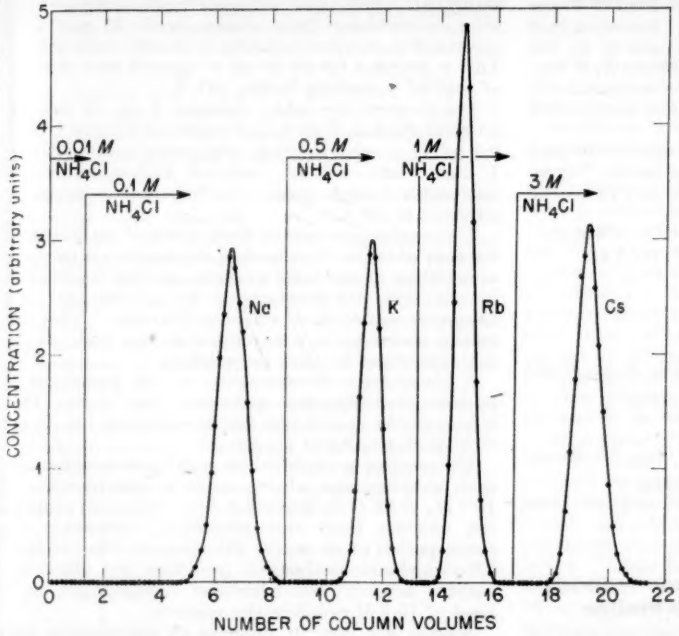

Fig. 1. Zirconium tungstate, 25° C.; column, 11·3 cm. × 0·13 cm.²; flow-rate, 1 cm./min.

While Fig. 1 represents separations of alkali metal tracers, similar separations can be achieved at macro concentrations.

This work was carried out for the U.S. Atomic Energy Commission at the Oak Ridge National Laboratory.

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Composition of Egg Phospholipids

THE fatty-acid composition of egg lecithin prepared by the cadmium chloride method has been determined by Riemenschneider *et al.*[1] and of total egg phospholipids by Shorland[2]. Their results agree in finding about 30 per cent of C_{16}, 55 per cent of C_{18} and 15 per cent of C_{20} and C_{22} acids; approximately 39 and 45 per cent, respectively, of the total acids were saturated.

It has been known for some years that the fatty acids split off from lecithin by the phospholipase *A* of snake venom are unsaturated, and more recently it has been proved that the enzyme removes these acids from the α′-position. Hanahan[3] has further shown that the fatty acids of the liver lecithins from various animals are not distributed at random between the two positions available, but that the α′-position is occupied by unsaturated acids only and the β-position exclusively by saturated. The same structure was found in egg lecithin (prepared by an alumina column method), where, moreover, the constituent acids were found to be entirely C_{18}[4]. This permitted the preparation of pure L-α-distearoyl lecithin by the hydrogenation of the natural material and then, by hydrolysis with lecithinase *A* or *C*, of pure L-α-monostearoyl lecithin[4] and of αβ-distearin[5].

Our work, however, suggests that the composition of egg lecithin is appreciably more complicated than that found by Hanahan for his alumina-column preparations.

In the first place, lysolecithins were prepared either by the action of snake venom on egg yolk followed by separation of the resulting lysophospholipids on a silica column, or by hydrolysis with venom of lecithins prepared on a silica column. In both cases they were found to possess a residual unsaturation of about 0·15 double bond per molecule, indicating the presence of a small proportion of lecithins containing two unsaturated residues in the molecule. This is in agreement with a failure to find more than 45 per cent of saturated acids in the total acids of egg lecithin.

Secondly, the fatty acids recovered from lysolecithin (which had been prepared by the action of venom on the intact yolk and represented 90 per cent of the original lecithin) have been examined, after hydrogenation, by partition chromatography according to Nijkamp[6] and found to consist of 33 per cent stearic and 67 per cent palmitic acid. This corresponds to a content of 33 per cent C_{18} acids in the egg lecithin, a figure similar to that found by the earlier workers.

Thirdly, acids with an average unsaturation of 5 (unconjugated) double bonds per molecule have been recovered from the α′-position of highly unsaturated lecithin fractions obtained from silica columns[7], and spectrophotometric examination after alkali isomerization has confirmed the presence of hexaene and tetraene acids. After hydrogenation the presence of C_{22} and C_{20} acids was demonstrated by the partition chromatogram.

It would appear on the basis of these results that not more than one-third, and possibly considerably less, of the lecithin of the egg yolks examined by us can have the simple di-C_{18} structure found by Hanahan for his alumina-column preparations, and that hydrogenation of lecithin obtained from eggs cannot therefore be relied upon to yield an individual distearoyl lecithin or its hydrolysis products by enzymic treatments.

It is well established that the fatty-acid composition of egg phospholipids is markedly dependent upon that of the dietary fats; but it seems unlikely that such a factor would account for the complete absence of C_{16}, C_{20} and C_{22} acids in the lecithin described by Hanahan.

Examination of the lysophosphatidylethanolamine obtained from venom-treated yolk has shown that its constituent acids also have a small unsaturation of the same order as that of the lysolecithins. In

this case the hydrogenated acids consisted of 47 per cent stearic and 53 per cent palmitic. Assuming that the action of the venom phospholipase is at the α′-position, as in the case of the lecithinase *A*, it may be concluded that the phosphatidylethanolamine of egg yolk has the same type of fatty-acid distribution as the lecithin.

A detailed account of this work, which forms part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research, will be published elsewhere.

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Characterization of an Enzyme reducing Pyrroline-5-Carboxylate to Proline

Several lines of evidence serve to establish glutamic-γ-semialdehyde as the key intermediate in the pathway of the biosynthesis of proline from either glutamic acid or ornithine[1,2]. Since glutamic-γ-semialdehyde spontaneously cyclizes nearly completely to Δ^1-pyrroline-5-carboxylic acid[2], hydrogenation of the latter becomes a key reaction in the biogenesis of proline.

An enzyme catalysing this reaction has been observed in extracts of mycelial pods of *N. crassa* and named pyrroline-5-carboxylate reductase[3]. Extracts of rat liver mitochondria have been shown to convert glutamic semialdehyde to proline; but efforts to increase the activity failed[4].

We have determined that pyrroline-5-carboxylate reductase occurs in the soluble proteins of liver. The enzyme has now been partially purified by ammonium sulphate fractionation and the hydrogen donor has been shown to be reduced diphosphopyridine nucleotide. The enzyme has also been characterized with respect to a number of its properties.

Assays of the enzyme are carried out by measuring the fall of absorption of reduced diphosphopyridine nucleotide at 340 mμ in the Beckman spectrophotometer as the reduction proceeds (see Table 1).

Table 1

Experiment	Change in optical density per 10 min.
1. Pyrroline-5-carboxylate + enzyme (0·8 mgm.) + DPNH	0·300
2. DPNH + enzyme (no pyrroline-5-carboxylate)	0·01
3. DPNH + pyrroline-5-carboxylate	0

The enzyme is prepared from rat liver homogenized in a Potter–Elvehjem homogenizer with 1·5 volumes of 0·025 *M* phosphate buffer at *p*H 8 and centrifuged at 100,000 *g* for 30 min. Neutral saturated ammonium sulphate is stirred into the supernatant fluid at 4° to obtain the fraction precipitating between 40 and 60 per cent saturation. This is reprecipitated, dissolved, then reprecipitated and subjected to successive elutions with 50, 45, 40 and 35 per cent saturated ammonium sulphate respectively. The solution resulting from elution with 35 per cent saturated ammonium sulphate is usually most active. This is dialysed for 18 hr. at 4° against four changes of 0·05 *M* phosphate buffer, *p*H 8.

The cuvette for assay contains 3 ml. of 0·05 *M* triethanolamine, 0·04 ml. of pyrroline-5-carboxylate, 0·1 ml. of enzyme solution, containing approximately 1 mgm., and 0·2 ml. reduced diphosphopyridine nucleotide (~0·5 mgm.). The total mixture is adjusted to *p*H 6·8.

The crude supernatant fluid contains an inhibitor fraction which is eliminated as the enzyme is purified. A doubling of the total enzyme activity is obtained in the first precipitation of the 40–60 per cent saturated ammonium sulphate fraction. This inhibitor seems to be precipitated at less than 40 per cent saturated ammonium sulphate.

A preliminary determination of the properties of pyrroline-5-carboxylate reductase has shown that it is unstable in acid and has an optimum *p*H at 6·8 in 0·05 *M* triethanol amine.

The enzyme is inhibited by *p*-chloromercuribenzoic acid, mercuric and silver ions at a concentration of 10^{-5} *M*. *BAL* (1-hydroxy-2,3-dithiolpropane) protects the enzyme from this inhibition, indicating the participation of an active SH group in the reaction. Ethylenediaminetetraacetic acid does not affect the enzyme activity, but adenosine triphosphate, at a level of 10^{-4} *M*, inhibits the reaction.

Studies are now in progress to characterize still further the properties of the enzyme and the inhibitor fraction.

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Effect of Reserpine on Serotonin in Rabbit Serum

It is generally accepted that the effect of clinical doses of reserpine on the circulation is central in origin and that such doses have no peripheral effect of any significance. It has recently been shown that reserpine and serotonin have similar effects on the central nervous system, and that relatively large doses of reserpine in dogs markedly increase the urinary secretion of a metabolite of serotonin[1]. It has therefore been suggested that certain actions of reserpine are mediated through the liberation of serotonin from the intestine[2].

We have shown that, in rabbits, relatively small doses of reserpine reduce the concentration of serotonin in the serum. In our experiments rabbit serum was tested on the rat œstrous uterus, and compared with known concentrations of 5-hydroxytryptamine creatinine sulphate. The accuracy of this method is about ± 10 per cent. The effect of the serum was presumed to be due to the serotonin content, as histamine does not affect the rat uterus and acetylcholine is not found in serum. As further proof of this presumption, it was shown that similar contractions, produced by the serum, and by

Table 1. Effect of Various Intravenous Doses of Reserpine on the Concentration of Serotonin in Serum from Four Rabbits (*a*) Before the Injections, (*b*) 17 hr. Later

Weight of rabbit (gm.)		3,010	2,870	2,770	2,870
Dose of reserpine (mgm.)		0·4	0·2	0·1	0·05
Serum conc. of serotonin (μgm./ml.)	(*a*)	4·35	4·35	4·35	4·35
	(*b*)	0·07	0·52	0·87	1·08

5-hydroxytryptamine, were antagonized to the same extent by ergot alkaloids.

We have not been able to demonstrate any antagonism between reserpine and serotonin *in vitro*. Even high concentrations of reserpine (10 μgm./ml.) have no effect on the sensitivity of the rat uterus to serotonin. Uteri from rats pretreated for several days with toxic doses of reserpine showed no change in sensitivity to serotonin as compared with normal preparations.

Fig. 1 and Table 1 demonstrate some of the results obtained after intravenous injection of reserpine. The serum content of serotonin falls rather rapidly; for example, it is reduced to half its original value two hours after a dose of 1 mgm. reserpine to a rabbit.

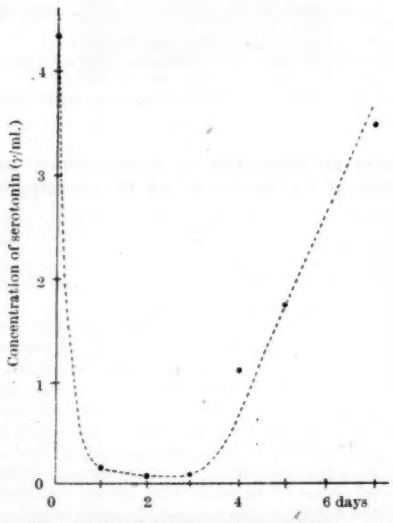

Fig. 1. Effect of three intravenous doses of 0·2 mgm. reserpine (at zero time and on each of the first two days) on the concentration of serotonin in serum. Rabbit weight: 3,350 gm.

We think that this effect can best be explained by a disappearance of serotonin from the platelets, these being the accepted source of the serotonin released during coagulation. The delayed disappearance of serotonin from the serum probably indicates an effect of a metabolite of reserpine rather than a direct effect of reserpine itself.

The possibility of a direct effect of reserpine on the platelets *in vitro* is now under investigation.

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Oxidation of Octanoic Acid by Cell-free Bacterial Extracts

Studies with extracts from the anaerobic organism *Clostridium kluyveri* have shown that certain fatty acids are oxidized to acetate by processes similar in essentials to those in mammalian systems[1]; but the mechanisms employed by aerobic bacteria have remained obscure. Thus, although results with whole cells of *Serratia marcescens*[2] did not apparently accord with β-oxidation, it has been shown more recently that extracts from *Pseudomonas fluorescens*[3] catalyse the formation of acetate from decanoate with the uptake of one micromole of oxygen per micromole of substrate. In experiments with cell-free extracts prepared from a vibrio[4], we have now been able to show that octanoic acid is oxidized by molecular oxygen to 2C units; that diphosphopyridine nucleotide, coenzyme A and magnesium ions are co-factors in this process; and that subsequent oxidation is by way of the tricarboxylic acid cycle.

After growth with forced aeration in a mineral-salt medium supplying octanoic acid as sole source of carbon[5], each 10 gm. (wet weight) of cells was crushed in a Hughes press[6] at − 14° C.; and while still frozen, the cells were ground in a mortar to a smooth paste with 10 gm. of alumina and 25 ml. of phosphate buffer. Centrifuging to remove alumina and cell debris gave clear extracts which contained about 18 mgm. protein per ml. and catalysed the oxidation of octanoate (Fig. 1). The rate of oxidation decreased with time, and the volume of oxygen utilized approached that for complete oxidation, namely, 11 moles oxygen per mole octanoate, when fumarate was added: thus four moles oxygen had been utilized in excess of the control after 40 min. and eight moles after 150 min.

The high rate of oxygen uptake in the absence of added substrate was largely abolished by dialysis against water or ethylenediamine tetraacetate, as shown in Fig. 2; and after this treatment, only

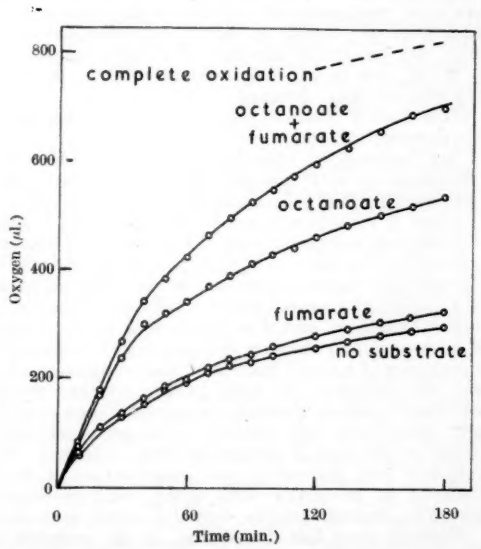

Fig. 1. Aerobic oxidation of octanoic acid by an undialysed extract. 2 μmoles of the substrates indicated were present with 1 ml. of extract in a total volume of 3 ml. Co-factors at concentrations given in Fig. 2 were also present

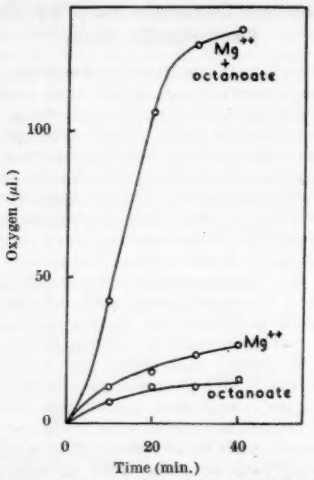

Fig. 2. Oxidation of octanoic acid by an extract dialysed for 3 hr. against ethylenediamine tetraacetate (0·02 *M*; *p*H 7·2). Reaction vessels contained, per 3 ml., 1 ml. of extract, 5 μmoles reduced glutathione, 0·1 μmole coenzyme A and 0·3 μmole diphosphopyridine nucleotide. Additions were as indicated: octanoate (2 μmoles) and magnesium sulphate to a final concentration of $1·3 \times 10^{-2}$ *M*

2·5–3 moles oxygen was then utilized when diphosphopyridine nucleotide and magnesium ions were added. In an experiment similar to that of Fig. 2, overnight dialysis against distilled water gave a preparation which oxidized 2 μmoles of octanoate, present in 3 ml. of reaction mixture, at the rate of 60 μl. oxygen per hr. when diphosphopyridine nucleotide was absent, and at 90 μl. oxygen per hr. on addition of 0·3 μmole of diphosphopyridine nucleotide. In these experiments, in addition to $1·3 \times 10^{-2}$ *M* magnesium sulphate, 0·1 μmole of coenzyme-A and 5 μmoles of reduced glutathione were also present. Subsequent experiments showed that the latter was not essential; but after treatment of extracts with 'Dowex-1' a stimulation of oxygen utilization by octanoate from 50 μl. per hr. in the absence of added coenzyme-A to 90 μl. per hr. in the presence of 0·1 μmole of coenzyme-A was obtained.

Oxidation of octanoic acid by dialysed extracts in the presence of added co-factors was accompanied by an increase in volatile fatty acid. After deproteinization with metaphosphoric acid, flask contents were distilled in an apparatus and approximately 6 μmoles of volatile acid were obtained from 2 μmoles of octanoate compared with the 8 μmoles of acetate required by the reaction $C_8H_{16}O_2 + 3O_2 \rightarrow 4CH_3COOH$. Further experiments, however, showed that addition of 5 μmoles of acetate caused a marked reduction in rate of oxidation, and it appeared that accumulation of acetate in the reaction mixture might inhibit the breakdown of a small fraction of the octanoate; this was also indicated by total oxygen uptakes rather less than the three molecules required. When volatile acid production was related to oxygen consumed, yields 90 per cent of theoretical were obtained. No keto-acid was detected; and examination of flask contents on extraction with ether, using gas–liquid partition chromatography, revealed acetic acid only.

Previous work has shown that, in the presence of fluoroacetate, this organism accumulates citrate during octanoate oxidation[7]; and cell-free extracts are able to oxidize citrate[8]. When this is considered with the present findings, it appears probable that octanoate is broken down to 2C units which are then oxidized by the reactions of the tricarboxylic acid cycle. Dialysis probably prevents the operation of the latter by removal of 4C compounds present in extracts; this observation points to the necessity of a mechanism for 4C replenishment by cells growing at the expense of fatty acids[5]. The tendency of free acetate to inhibit octanoate breakdown suggests the existence of a regulatory mechanism maintaining a balance between the rates of operation of the fatty acid[9] and tricarboxylic acid cycles.

I wish to thank Mr. J. R. L. Walker for his assistance in the determination and identification of acetic acid; Mr. T. J. Bowen, who constructed the apparatus for vapour-phase chromatography; Mrs. M. Lees for skilful technical assistance; and the Agricultural Research Council for a grant.

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Bacterial Variation to Sensitivity: an Example of Individuality in Micro-organisms

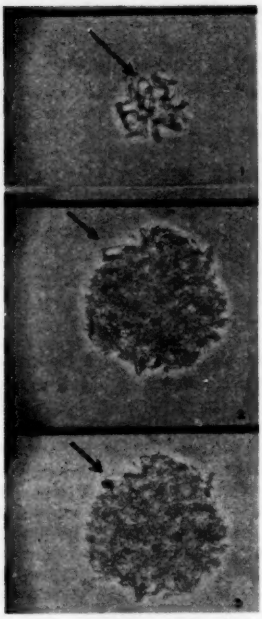
It is now a commonplace that, in culture, resistant organisms may be already present before there has been any contact between them and an antibiotic[1]. I demonstrated[1,2] that this was true even in young cultures derived from single cells.

While it has been relatively easy to demonstrate that there is a regular distribution of resistance through these populations, there has not so far been any published evidence that increased sensitivity was similarly distributed. There is evidence of the production of true-breeding mutants which are many times more sensitive than the parent strain[3]; but this is a different order of phenomenon from the graduated series of variants here being considered.

If phase-contrast microscopy be supplemented by time-lapse ciné-micrography, it is possible to demonstrate that organisms more sensitive than the parent cell are produced in micro-colonies in 'sub-inhibitory' concentrations of antibiotic. These cells are not normally noticed since they are eliminated by lysis, leaving nothing to indicate that selection has been at work. The alternative method, which involves the testing of individual organisms by transferring them singly to antibiotic agar or other unfavourable environment, is so laborious that only a few generations can be studied[3].

The results shown by ciné films have been so instructive that it seems justifiable to report a typical preliminary finding here.

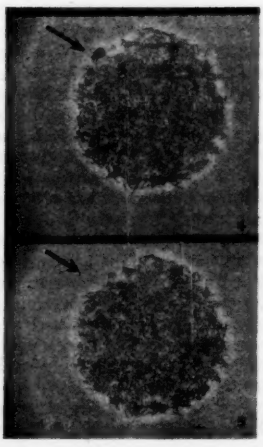
Fig. 1 shows a young colony derived from a single cell and growing on one-fifth of the normal inhibitory dose for the strain. Of the individual cells present, only one, marked with an arrow, is sensitive at this level of penicillin. Fig. 2 is of the same colony 230 min. later; it shows that this cell alone has failed to divide. Fig. 3 is the next frame in the film, only



20 sec. later, and records the bursting of this cell. Its contents flow out and are visible for 23 min., but then disappear between one frame and the next (Figs. 4 and 5), leaving nothing that can be resolved by the light microscope.

At higher concentrations of antibiotic, this individuality of reaction in cells derived from a single parent can also be seen. In a field of three or four organisms, all inhibited for division but able to grow in size, it is usual to find at least one that is obviously more sensitive and is destroyed while its fellows survive to give rise to fresh generations many hours later. Some sensitive cells appear in the cultures no matter how often the strain has been exposed to the antibiotic.

I therefore feel justified in advancing the hypothesis that, whenever a microbe divides, the daughter cells will differ from one another and from the parent cell from which they came. The so-called 'clone' of organisms is a population of separate individuals normally distributed for any measurable character and subjected to continuous re-selection by an unfavourable environment. Selected populations are not soon permanently altered, as they would be by mutation proper, but will show similar reactions at each fresh contact with the unfavourable environment.



In reviewing the records made during the eight years in which phase-contrast microscopy has been available, I have never observed anything that might throw doubt on this hypothesis. Photographs and films published by others also support this view. Vadasz and Juhasz[4], although primarily interested in the origin of resistance, show pictures of *Salmonella enteritidis* similar to ours with *Proteus vulgaris*. Further evidence is available from such divers fields as Lwoff and Gutmann's[5] studies on phage production in *Megatherium* and Crawley and Jevons's[6] recent publication on the synthesis of carbohydrate by streptococci.

The supervision of the ciné-micrographic technique used was in the hands of Dr. Peter N. Cardew, of the Photographic Department, St. Mary's Hospital Medical School, and the apparatus was designed and largely built by him.

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Free Amino-acid Content of the Lymph

We have been studying the free amino-acids of the blood and urine by quantitative paper chromatography[1]. This method also offered the possibility of extending our researches on lymph and of comparing the free amino-acid content of lymph and blood obtained from different areas.

Our experiments were carried out on six dogs. Under 'evipan'-anæsthesia we isolated the thoracic duct, the cervical lymph ducts and the lymph duct running along the vena portæ, and gathered lymph through cannulæ. At the same time, we drew blood from the jugular vein and from the portal vein too.

In these samples the free amino-acids were determined in the following way. The deproteinization of the blood or lymph was carried out by alcoholic precipitation and the removal of lipids by shaking with ether. Desalting was done by the method of Consden and Gordon. The amino-acids were separated by two-dimensional ascending paper chromatography in a phenol/*n*-propanol/water, or in some cases in a phenol/*n*-butanol/acetic acid/water solvent system. The principle of the method of determination was to make the amino-acids visible by spraying the paper with diluted ninhydrin solution, removing the ammonia-like impurities of the paper by spraying it with alcoholic potash solution. The spots were cut out and their amino-acid content determined by our previously published method[2] with recent modifications (unpublished). The ninhydrin reagent used in

Table 1. Amino-acid Concentrations (μgm./ml.)

	Jugular vein		Portal vein		Thoracic duct		Cervical trunk		Liver lymphatic	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
Alanine	19–52	32·8	27–53	35·6	17–47	30·7	28–44	35·2	22–43	29·6
Arginine	7–16	12·3	9–18	14·0	8–19	11·6	7–14	10·8	7–10	8·8
Aspartic acid	2–6	3·8	3–4	3·2	2–6	4·2	3–4	3·3	2–3	2·7
Cystine	6–21	12·2	5–16	8·8	5–16	10·2	5–19	12·3	4–7	6·0
Glutamine	38–88	58·2	34–72	50·7	32–80	55·3	42–85	63·0	33–70	46·2
Glycine	8–20	11·8	9–17	13·8	6–14	10·3	6–21	12·5	8–18	11·6
Histidine	7–12	10·0	5–17	8·6	4–15	11·0	9–11	10·0	8–12	9·5
Leucine + isoleucine	13–24	19·3	13–26	19·0	14–30	19·2	6–18	13·2	12–27	19·8
Lysine	7–16	11·2	5–17	10·0	4–19	8·5	7–12	9·0	3–10	6·6
Phenylalanine	6–12	8·5	7–14	10·2	6–21	12·7	7–10	7·8	8–19	11·6
Proline	17–22	19·0	16–23	19·5	12–20	15·0	10–20	15·0	12–18	15·0
Serine	6–12	9·0	5–11	7·4	5–14	9·6	8–13	10·7	6–14	8·5
Threonine	9–28	20·7	16–28	19·8	12–31	20·0	12–25	18·8	11–21	18·4
Tyrosine	8–15	12·4	8–17	12·2	7–18	12·3	8–15	10·0	7–18	12·6
Tryptophan	6–13	8·5	8–11	9·3	11–17	14·7	6–8	6·7	11–15	14·7
Valine	10–18	14·0	11–21	15·2	9–22	14·8	7–17	12·0	12–19	15·4

this method is similar to that of Moore and Stein[3]. The determination of proline was made by our modification of Schweet's method[4]. In accordance with Stein and Moore's results[5] we also observed that glutamine may be slightly decomposed during the procedure. To minimize this error, the standard glutamine solution was submitted to the same procedure before determination. The relative limit of our method is about ± 10 per cent. The results are given in Table 1.

Summing up our observations: (1) the amino-acid pattern of lymph is similar to that of the serum; (2) in some experiments we have found striking differences in the concentration of individual amino-acids of different samples, certainly exceeding the error of our method (see detailed publication in *Acta Med. Hung.*, in the press), but systematic, unidirectional differences were not to be found; (3) the amino-acid in the highest concentration in all materials was glutamine, that in lowest concentration aspartic acid.

The concentration of individual amino-acids in the systemic blood and portal vein in dogs was investigated recently by Denton and Elvehjem[6]. Comparing our results with theirs, the values for arginine, histidine, leucine, phenylalanine, threonine, tryptophan and valine correspond, despite the diversity of the methods. Our determinations of histidine, phenylalanine, tryptophan and tyrosine agree also with the results of Hier and Bergeim[7]. In disagreement with the available data on dog plasma, the concentration of lysine is comparatively low. This may be connected with the loss of this amino-acid arising from the method of preparation (for example, desalting). This problem has not been dealt with in detail.

Our investigations will be published fully in *Acta Med. Hung.*

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Reciprocal Egg Transplantations to study the Embryo–Uterine Relationship in Heat-induced Failure of Pregnancy in Rabbits

Pregnancy in rats[1], mice[2] and ewes[3] is adversely affected by high ambient temperature. Experiments described here were undertaken to see if rabbits, too, fall in this category; and if so, whether the heat acts directly on the embryos, the uterus, or both.

In the first experiment, the course of pregnancy was studied in eight rabbits, following continuous exposure to high temperature for six days following copulation. The heat-treatment was carried out in a thermostatically controlled chamber. The average air temperature was 95·9° F. dry-bulb and 78·8° F. wet-bulb. This raised the rectal temperature of the rabbits from an average of 102·5° F. in the normal environment to 105·1° F. during the six-day period of heat-treatment. Before and after heat-treatment the rabbits were kept in the normal environment. The course of pregnancy was followed by laparotomy between the tenth and fifteenth day post-coitum, by abdominal palpation of conceptuses, and by autopsy in cases of pregnancy interruption. Prenatal losses were estimated by the method of Allen, Brambell and Mills[4]. Entire litters were resorbed in seven of the eight heat-treated rabbits, and a partial resorption occurred in the eighth doe, in which two out of five conceptuses, observed at laparotomy, were carried to term. Observation of corpora lutea, implantations and resorptions of embryos in the eight heat-treated rabbits revealed that, on the basis of ovulations, prenatal losses were 96·2 per cent, of which 75·6 per cent occurred by way of resorptions following implantation. Pre-implantation losses were unaffected. Thus a continuous exposure of rabbits to high air-temperature during the pre-implantation period of pregnancy (six days post-coitum) resulted in severe prenatal mortality through resorption of embryos, following normal implantation. The resorptions occurred mainly between the tenth and fifteenth day of pregnancy and to a smaller extent after the twenty-first day. Control experiments showed that the interruption of pregnancy was unrelated to a lowered food intake during heat-treatment, or to laparotomy.

In the second experiment the technique of egg transplantation was employed to study the embryo–uterine relationship in this interruption of pregnancy. Normally, transplantation of six-day rabbit eggs would involve incision of the uterus of a pseudo-pregnant recipient for transfer of eggs[5]. However, in the transplantations reported here uterine incision was avoided by transferring eggs to the uterus via the cervix through an incision in the vaginal canal

of laparotomized recipient females. Pyometra, usually encountered following transplants in the presence of active corpora lutea in rabbits[6], was obviated by the local use of aureomycin and intramuscular injections of penicillin. Using this technique, thirty-two six-day eggs from unheated donor rabbits were transferred to the uteri of five unheated six-day pseudopregnant recipients. In all, twelve normal young were born to four of five recipients, representing a normal development to term of 37·5 per cent of transferred blastocysts. These transplantations, in which both donors and recipients were kept in the normal environment, formed the controls for experiments three and four, involving heat-treatment of either donors or recipients.

In the third experiment, thirteen donor rabbits were subjected to heat-treatment for six days (144 hr.) following copulation with fertile bucks. At the end of heat-treatment they were killed and seventy-four blastocysts were collected, which represented 72·5 per cent of 102 ovulations (on the basis of corpora lutea). This figure compares favourably with a 74·4 per cent recovery of six-day blastocysts from normal unheated donors[7]. Forty-two six-day eggs from the heated donors were transferred to the uteri of eight unheated six-day pseudopregnant recipients. Seven of the eight recipients produced fifteen normal young, representing a development to term of 35·7 per cent of eggs transplanted against 37·5 per cent in control transplantations. Thus, embryos recovered from donors heat-treated for a period of six days post-coitum undergo normal development to term in the uteri of unheated pseudopregnant recipients. This shows that embryos up to six days of age are unaffected by heat—a finding which is substantiated by the fact that a similar number of blastocysts may be recovered at six days from either heated or unheated donors.

In the fourth experiment, all donors were kept in the normal environment, but recipient rabbits were subjected to continuous heat-treatment for 144 hr. following mating to vasectomized bucks. Sixty-six six-day blastocysts from unheated donors were transferred to the uteri of nine heat-treated six-day pseudopregnant recipients. Recipients were left in the normal environment following transplantation, and pregnancy was diagnosed by abdominal palpation at regular intervals. Recipients were autopsied if and when their pregnancies were diagnosed as regressing. Implantation of transferred embryos occurred in all nine heat-treated recipients; but at stages subsequent to implantation entire litters were resorbed in eight of them. In these eight recipients, resorption of embryos occurred mainly between the twelfth and fourteenth day post-coitum, and to a smaller extent after the twentieth day. The ninth doe, which was killed on the tenth day post-coitum, appeared to have normal conceptuses at that time; but these perhaps would have resorbed had the animal not been autopsied prematurely. From this experiment it is clear that when six-day blastocysts from unheated donors are transplanted to heat-treated pseudopregnant recipients, embryos become implanted, but most of them afterwards undergo resorption. This shows that continuous heat-treatment for six days renders the uterus unsuitable for the normal development of embryos.

These experiments have shown that normal pregnancy in the rabbit was interrupted by high temperature during the first six days of gestation. This was caused by heat acting adversely on the maternal tissues rather than directly on the embryos themselves.

My thanks are due to the Government of the Commonwealth of Australia for the award of a junior fellowship under the Technical Co-operation Scheme of the Colombo Plan, enabling me to carry out this work; to the Government of India for sponsoring my application; to the University of Queensland for extending research facilities; to Dr. N. T. M. Yeates, of the Commonwealth Scientific and Industrial Research Organization of Australia, for his continued guidance; and to Prof. W. V. Macfarlane and the staff of the Physiology School, University of Queensland, for their help.

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Determination of Sex in Early Human Embryos

The presence of sex-chromatin in cell nuclei is being noted in an ever-increasing number of tissues from human and animal females[1–9]. Popular interest was roused recently by a report in *Nature*[10] describing a method of antenatal sex determination. The method depends on the presence or absence of sex-chromatin in desquamated cells isolated from amniotic fluid.

An examination has now been carried out of the human embryos and fœtuses in this Department. The collection comprised twenty-two male and twelve female fœtuses, ranging in size from 18 to 150 mm. crown-rump length. All the specimens have been stained with hæmatoxylin and eosin. Most of the specimens were sufficiently well fixed and stained for nuclear details to be observable.

The presence of a dark-staining plano-convex particle in contact with the nuclear membrane of vesicular, 'open-faced' nuclei was taken as indicating the presence of sex-chromatin. Shrunken, pyknotic, too densely stained nuclei, or those overlapped by other structures, were unsuitable for study. Using these criteria, the presence or absence of sex-chromatin corresponded in each case with the sex of the fœtus as determined by the histological appearances of the gonads. Sex-chromatin particles were identified in 30–50 per cent of nuclei examined in the tissues of the female fœtuses. Although sex-chromatin could be identified in many tissues, the nuclei most suitable for examination were found in the liver, suprarenals, mesonephric tubules, surface epithelium, cardiac muscle, undifferentiated mesenchyme, notochord and cartilage. However, the latter was often insufficiently well preserved to be reliable. It should also be noted that the morphological sex differences described above are also demonstrable in both layers of the trophoblast.

In male fœtuses doubtful nuclei were occasionally encountered but they never exceeded 10 per cent of

the nuclei counted. A closer examination of these nuclei usually revealed a degree of irregularity of the nuclear membrane. As there appears to be a concurrence between the incidence of sex-chromatin in fœtal cells and the presence of ovarian characters in the gonad, young embryos in which the gonad had not yet differentiated into a testis or ovary were examined. Thirteen embryos were suitable for this examination, and six were found to possess a sufficient number of nuclei containing sex-chromatin to warrant their classification as females. The youngest specimen showing this feature was a 1·7 mm. pre-somite embryo. In addition, the syncytiotrophoblast cells of an implanting blastocyst were seen to contain the sex-chromatin particles, although the cells of the embryonic disk and the cytotrophoblast were not suitable for the test.

These results are presented as they appear to be significant, and the method may prove useful in the determination of sex in early embryos. It is realized, however, that more specimens will have to be examined and more experience gained before the test can be said to be entirely reliable.

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Effect of Electric Shock and Cardiazol Shock on Morphine Tolerance

During my investigation of the tolerance for morphine and codeine using 'coughing dogs'[1], I noted that acquired tolerance for these drugs by which their antitussive effects were completely lost was reduced or eliminated by an electric shock or a cardiazol shock. Morphine (2–6 mgm./kgm.) given intravenously completely depressed coughing for 1–6 hr. in such dogs on the first day of administration. By continued daily application of the drug, the dogs acquired tolerance in five to ten days; but the same drug failed to depress coughing afterwards. Similar tolerance for codeine developed in eight to fourteen days. The dogs thus made tolerant for morphine or codeine were subjected to an electric shock (a.c. 90–100 V., 2 sec.) or cardiazol shock (30–50 mgm./kgm.). On the following day, each antitussive drug was one-fourth to three-fourths as potent, or in a few cases, quite as potent, as on the first day of administration, indicating that the shock had reduced or eliminated the tolerance.

The effect of the first shock persisted for three to four days, after which another shock was required to eliminate the redeveloped tolerance. Neither of the shock therapies affected the antitussive action of morphine in any non-tolerant dogs, and the combined application of morphine and electric shock for many consecutive days failed to prevent the animals from acquiring tolerance for morphine. Excepting the rare cases, the effect of an electric shock or cardiazol shock was proportional to the severity of the resulting convulsion and excitement.

From the following observations it is presumed that the effect of shock may in part be ascribed to the increased permeability of cerebral blood vessels and brain tissue. (1) Intravenously administered trypan blue, which left brain and spinal tissue unstained in normal dogs[2], stained brain tissue blue when accompanied by an electric shock (however, the nerve cells contained none of the dyestuff). (2) Hyaluronidase (10,000 v.r.u./kgm.) mixed with morphine reduced tolerance without causing convulsions, though the effect was far weaker than that of an electric shock. Brain tissue was also stained with trypan blue during hypertension produced with adrenaline; but the hypertension itself did not reduce the tolerance for morphine.

These facts suggest that the staining of brain tissue with trypan blue after application of an electric shock is mainly attributable to enhanced permeability of cerebral blood vessels due to the hypertension induced by convulsion, and that the effect of the shock on morphine tolerance may be based on its action of enhancing the permeability of brain tissue (especially the nerve cells themselves). Possibly the effect of shock therapy on a narcotic addict is in part based on the reduction of drug tolerance described above.

Further investigations have shown that: (1) tolerance can be acquired only when morphine reaches the central nervous system via blood vessels, and not via the cisterna cerebellomedullaris, for the tolerance developed in five to fourteen days by intravenous or intra-arterial injection (common carotid artery), but never developed by daily intracisternal injection for six months; (2) when complete tolerance was obtained by daily intravenous administration of such a dose of morphine that would give much longer duration of antitussive effect than that given intracisternally, the same dose as that administered intracisternally before was given into the cisterna again; however, tolerance did not affect the intracisternal effect, that is, the intracisternal effect was almost equal to that before tolerance had been acquired.

Y. Kasé

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[1] Kasé, Y., *Jap. J. Pharmacol.*, **4**, 130 (1955).
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Hair-line Cracks in Low-alloy Steels

The cause of hair-line cracks in low-alloy steels has been debated for many years. The main hypotheses now current can be reduced to the following: the hydrogen-pressure hypothesis and the residual stress hypothesis. It follows from the former that hydrogen alone can induce hair-line cracks to form; and from the latter that, in the absence of residual stress, no hair-line cracks will form even if hydrogen is present.

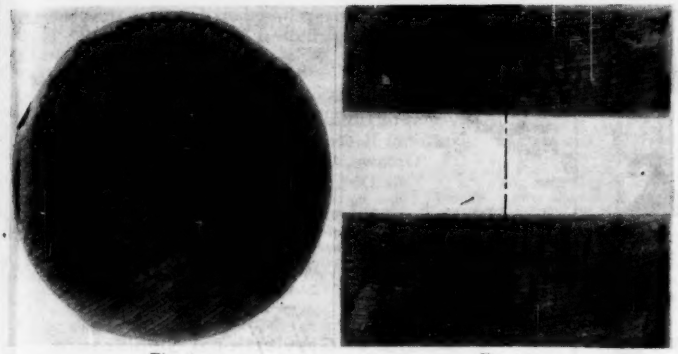

Fig. 1 Fig. 2

(1) Transverse section at mid-length. (2) Longitudinal section. The centre line is vertical. The missing centre portion is where the section shown in Fig. 1 was taken. Magnetic etch. Diameter of the section, 4 in.

Dana, Shortsleeve and Troiano[1] have recently studied the effect of transformations and hydrogen content on the formation of hair-line cracks. One of the conclusions reached was that transformation stresses must be present for cracks to form. Petch[2] also concludes that the hydrogen-pressure hypothesis is not likely to explain hair-line cracking.

We have carried out experiments in which cylinders of steel 4 in. in diameter × 4 in. long have been saturated with hydrogen at 100 atmospheres pressure at subcritical temperatures (between 600° and 650° C.), the specimens afterwards being air-cooled. Under these conditions, no transformation takes place and the residual stress after treatment at 600° C. and air cooling will be small.

By this means, hydrogen contents of between 12 ml. and 14 ml./100 gm. have been obtained in several steels. Plain carbon steels with 0·1 per cent carbon did not contain hair-line cracks after this treatment. With steels of the following composition :

	C	Si	Mn	Ni	Cr	Mo
Steel *A* :	0·28	0·26	0·62	2·76	0·77	0·54 per cent
Steel *B* :	0·30	0·19	0·42	4·22	1·27	0·16 per cent

typical hair-line cracks have been found to form.

An example is shown of steel *A* (Fig. 1), originally oil-quenched and tempered at 630° C. followed by hydrogen treatment at between 570° C. and 620° C. for 20 hr. Supersonic examination showed small hair-line cracks on cooling to room temperature, which gradually increased in size and number with time. The sections shown were obtained 120 hr. after air cooling. The hardness was 280 V.D.H. after treatment. In all cases, supersonic examination showed that the specimens were free from hair-line cracks before the hydrogen treatment.

Houdremont and Schrader[3] have described an experiment in which 2½-in. diameter specimens of a nickel chromium steel of similar composition to steel *B* (Fig. 2) were exposed to hydrogen at 1,000 atmospheres pressure and 550° C. and then either water-quenched or furnace-cooled. Many hair-line cracks were present after water quenching, but only a few in the furnace-cooled specimen. Although about three times the hydrogen content would be present at a temperature compared with the experiments described above, the relatively small size of the specimen would result in much more hydrogen being lost from the centre of the specimen in the slow-cooling treatment than would be the case with the 4-in. cylinders in our experiments.

These experiments indicate that hair-line cracks can form when residual stresses are very low. The local stresses caused by hydrogen pressure are insufficient to crack the softer mild steels, but are sufficient to cause brittle fracture in the nickel steels. Residual stresses due to both transformation and cooling effects would be expected to be additive to the basic hydrogen pressure-induced stresses. In most practical cases the macro residual stresses will be low ; but the micro transformation stresses are likely to be of considerable importance.

We wish to thank the directors of Thos. Firth and John Brown, Ltd., for permission to publish this communication.

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Jan. 6.

[1] Dana, A. W., Shortsleeve, F. J., and Troiano, A. R., *J. Metals*, **7**, 895 (1955).
[2] Petch, N. J., "Residual Stresses in Metals and Metal Construction" (Reinhold, 1954).
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Dependence of Snowfall on Temperature

D'Ooge has reported[1] a correlation between amount of snowfall in inches and temperature at the time of snowfall. His data showed that maximum depth of snowfall occurred at a daily mean temperature of − 11° C. ; Bossolasco[2] correlated frequency of occurrence of snowfall with temperature and found maximum occurrence at approximately the same temperature. These observers assumed that the mean daily temperature recorded at the level of observation was a reasonable estimate of the temperature at the level of formation of the snow. From the data presented, conclusions were drawn concerning nucleation of snow crystals.

The dependence observed by D'Ooge was checked by analysing, on a monthly basis, data collected by the Canadian Meteorological Service at Old Glory Mountain (elevation 7,700 ft.) over the period 1947–55. The observed dependence of inches of snowfall on the mean daily temperature is shown in Fig. 1. Assuming that the distributions are due to a real dependence of the amount of snowfall on the temperature at which the snow is forming, Fig. 1 indicates that only during the midwinter months are the temperatures measured at the level of observation likely to be a reasonable estimate of the temperature at the level of formation. The distributions for the remaining months are shifted to higher temperatures, as would be expected when the effect of the annual variation in mean temperature at the ground is taken into account.

It was pointed out to us by members of the Canadian Meteorological Service that these distributions do not necessarily show a true correlation of amount of snowfall on temperature. Other possible explanations exist ; for example, the observed

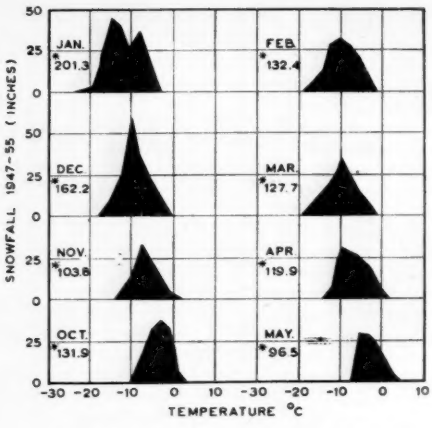

Fig. 1. Dependence of monthly snowfall on temperature at Old Glory Mountain for period 1947–55
* Total snowfall in inches, 1947–55

distribution may be a reflexion of the frequency distribution of the temperatures at the fixed level of observation. Data were available from observations taken at Montreal during the winter of 1951–52 [3] which gave the depth of snowfall and the temperature at the level of formation as estimated from the meteorological records. The distribution obtained from these data is shown in Fig. 2. The area enclosed in the distribution corresponds to 89 in. of the winter total of 124 in. Assuming that air masses in which the snow forms will not produce precipitation until conditions are favourable, Fig. 2 should be a true correlation between amount of snowfall and the temperature at the level of formation. From this distribution it is seen that the greatest amount of snow is likely to come from cloud between − 10° C. and − 20° C. One interesting feature of the Montreal observations was that the majority of snow crystals were irregular assemblages of columns and plates[4]. The distribution in inches for the snowfalls observed was: 59·0 in., irregular crystals (usually associated with frontal storms); 15 in., dendrites; and the remainder, columns and needles. According to Nakaya, irregular assemblages of columns and plates form over the temperature ranges − 9° C. to − 14° C. and − 17° C. to − 20° C.; dendrites form in the temperature range − 14° C. to − 17° C.

Since it is very difficult to estimate the temperature of formation of the snow, and since this temperature is not likely to remain constant throughout a snowfall,

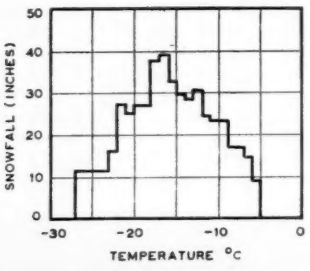

Fig. 2. Dependence of snowfall on temperature from observations made at Montreal

any conclusions drawn based on details in the observed distributions must indeed be speculative.

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Dec. 20.

[1] D'Ooge, C. L., *Nature*, **175**, 465 (1955).
[2] Bossolasco, M., *Geofisica Pura e Applicata*, **28**, 208 (1954).
[3] Gold, L. W., and Power, B. A., *J. Meteor.*, **11**, No. 1, 35 (1954).
[4] Nakaya, U., "Snow Crystals: Natural and Artificial" (Harvard Univ. Press, 1954).

Results of Gravitational Significance in Riemannian Geometry

It is well known that by contraction one can deduce from the Bianchi identities in Riemannian geometry the following result:

$$R^h_{ijk\,;\,h} = R_{ij\,;\,k} - R_{ik\,;\,j} \qquad (1)$$

From this it follows that if:

$$R_{ij} = \lambda g_{ij} \qquad (2)$$

which is the usual condition for an Einstein space, then:

$$R^h_{ijk\,;\,h} = 0 \qquad (3)$$

This implies:

$$\text{(i)}\quad C^h_{ijk\,;\,h} = 0, \quad \text{(ii)}\quad W^h_{ijk\,;\,h} = 0 \qquad (4)$$

for the conformal and projective curvature tensors in Eisenhart's[1] notation. The gravitational significance of (3) and (4) does not appear to have been examined so far, although (4i) has received some attention in a particular context[2].

For an arbitrary contravariant vector field a^m we have:

$$a^m{}_{;\,ln} - a^m{}_{;\,nl} = a^p R^m_{pnl} \qquad (5)$$

Hence, by contraction ($m = l$), we get:

$$a^m{}_{;\,mn} - a^m{}_{;\,nm} = a^p R_{pn} \qquad (6)$$

If now (2) is used, (6) is reduced to:

$$a^m{}_{;\,mn} - a^m{}_{;\,nm} = \lambda a_n \qquad (7)$$

The cosmological constant λ is now given by:

$$\lambda = a^n(a^m{}_{;\,mn} - a^m{}_{;\,nm})/a^l a_l \qquad (8)$$

which shows how the constant can be interpreted in terms of operations on an arbitrary non-null vector field a^n. From (7) we can also deduce that:

$$a^m{}_{;\,nml} - a^m{}_{;\,lmn} = \lambda(a_{l\,;\,n} - a_{n\,;\,l}) \qquad (9)$$

If the gravitational field is given by $R_{ij} = 0$, the essence of the equations is contained in the fact that an arbitrary vector field a^n satisfies the condition:

$$a^m{}_{;\,mn} - a^m{}_{;\,nm} = 0 \qquad (10)$$

It is believed that the gravitational significance of (8) and (10) has not been noticed so far.

V. V. Narlikar

Department of Mathematics,
Banaras Hindu University.
Dec. 31.

[1] Eisenhart, L. P., "Riemannian Geometry", 82, 91 and 135 (Princeton, 1926).
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FORTHCOMING EVENTS

Monday, June 18

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. A. W. Stonier: "The Influence of Philosophy in Economics".

Wednesday, June 20

INSTITUTE OF NAVIGATION (at the Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. George Lowe: "Crossing Antarctica".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Special General Meeting to elect Officers and Council for 1956–57. Mr. N. A. Phillips: "The General Circulation of the Atmosphere—a Numerical Experiment".

Wednesday, June 20—Thursday, June 21

POLAROGRAPHIC SOCIETY (in the Chemistry Lecture Theatre, Battersea Polytechnic, Battersea Park Road, London, S.W.11), at 10 a.m. daily—Symposium on "Polarography and Medicine".

Thursday, June 21

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Annual General Meeting; followed by Prof. P. C. C. Garnham: "Looking for Parasites in Brazil—an Illustrated Account of a Journey".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN PSYCHOLOGY—The Secretary, The Queen's University, Belfast (June 20).

LECTURER (with a good degree and suitable teaching experience) IN MATHEMATICS—The Principal, Leeds College of Technology, Cookridge Street, Leeds 2 (June 20).

SENIOR ENTOMOLOGIST, and an ENTOMOLOGIST, IN THE DEPARTMENT OF RESEARCH AND SPECIALIST SERVICES, Federal Ministry of Agriculture, Federation of Rhodesia and Nyasaland—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (June 20).

ASSISTANT, Grade B (with teaching and research experience) IN ZOOLOGY—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (June 23).

BIOCHEMIST (honours science graduate) for research duties in the Geriatric Department of the Sunderland Hospital Group—The Senior Administrative Medical Officer, Newcastle Regional Hospital Board, Walker Gate Hospital, Benfield Road, Newcastle-upon-Tyne 6 (June 23).

CHEMIST (with a first- or good second-class honours degree or equivalent qualification and at least three years experience, and preferably a knowledge of liquid fuels and lubricants) at the Central Laboratory, Chiswick—The Recruitment and Training Officer (F/EV.587), London Transport, 55 Broadway, London, S.W.1 (June 23).

RESEARCH ASSISTANT (with a good honours degree in physics and preferably some research experience) IN THE PHYSICS DEPARTMENT—The Head of the Physics Department, Imperial College of Science and Technology, London, S.W.7 (June 27).

STATISTICIAN or MATHEMATICIAN (preferably with a university degree in mathematics or statistics or equivalent qualifications) at Headquarters, London, S.E.1, to assist in a section devoted to system operation research, and will be expected to apply original mathematical ideas to the short-term and long-term planning of the system—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. AE.832 (June 29).

ASSISTANT FORESTERS and FORESTERS (graduates of a recognized forestry school), to assist in the management of large-scale softwood plantations, including establishment maintenance, protection and utilization, or assist in research—The Agent General for South Australia, South Australia House, Marble Arch, London, W.1 (June 30).

ASSISTANT LECTURER (graduate in physics, chemistry, metallurgy, biology or engineering) IN DENTAL MATERIALS—The Registrar, The University, Manchester 13 (June 30).

ASSISTANT LECTURER (with special qualifications either in mycology and soil microbiology or in plant physiology) IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Bristol (June 30).

DIRECTOR OF THE COMPUTING LABORATORY, situated in Newcastle-upon-Tyne—The Registrar, University Office, 46 North Bailey, Durham (June 30).

LECTURER IN ENGINEERING (Civil)—The Registrar, The University, Manchester 13 (June 30).

LECTURER IN GEOGRAPHY, and a LECTURER IN CHEMISTRY, at the Nigerian College of Arts, Science and Technology—The Secretary, Advisory Committee on Colonial Colleges, 1 Woburn Square, London, W.C.1 (June 30).

RESEARCH ASSISTANT (with a degree in agriculture, with special reference to animal husbandry or production), for investigations on carcase quality of beef—The Secretary, School of Agriculture, The University, Cambridge (June 30).

TECHNICAL ASSISTANT (Display) IN THE DEPARTMENT OF ARCHÆOLOGY AND ETHNOLOGY; and a TECHNICAL ASSISTANT IN THE DEPARTMENT OF NATURAL HISTORY—The Director, Liverpool Public Museums, Carnatic Hall, Elmswood Road, Liverpool 18 (June 30).

RESEARCH STUDENTS (with a degree of Bachelor or Master of a British university, other than Manchester) IN SCIENCE—The Registrar, The University, Manchester 13 (July 1).

LECTURER or ASSISTANT LECTURER (with special interest in inorganic chemistry) IN CHEMISTRY—The Registrar, The University, Sheffield (July 2).

SENIOR LECTURER, LECTURER, and ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Manchester 13 (July 4).

ASSISTANT LECTURER (with an honours degree) IN PSYCHOLOGY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (July 6).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS, at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 6).

READER IN ELECTRICAL ENGINEERING at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (July 6).

SOIL ANALYST (with a degree or equivalent qualification in chemistry, and at least two years subsequent experience), at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 6).

SOIL MICROBIOLOGIST (with a good honours degree and practical experience)—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (July 6).

ASSISTANT (male, with a degree in horticulture, agriculture or botany, together with a keen interest in the scientific aspects of practical fruit culture, and ability to convey the results of research to scientists, advisory officers and growers) IN THE SCIENTIFIC LIAISON SECTION—The Secretary, East Malling Research Station, near Maidstone, Kent (July 7).

PRINCIPAL (male, graduate of a British university, with teaching and, if possible, some administrative and industrial experience) OF THE BRADFORD TECHNICAL COLLEGE—The Director of Education, Town Hall, Bradford 1 (July 7).

SENIOR LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Sheffield (July 7).

DEMONSTRATOR or ASSISTANT LECTURER (with a medical qualification registrable in this country) IN PHYSIOLOGY—The Registrar, The University, Manchester 13 (July 9).

ASSISTANT (preferably with qualifications in psychology) IN THE DEPARTMENT OF LOGIC AND METAPHYSICS in St. Salvator's College, St. Andrews—The Joint Clerk to the University Court, College Gate, St. Andrews (July 14).

LECTURER or ASSISTANT LECTURER (with qualifications in physical or inorganic chemistry, and preferably with experience in radiochemistry) IN CHEMISTRY—The Registrar, The University, Hull (July 16).

FELLOW AND TUTOR IN PHYSICS—The Warden, Merton College, Oxford (July 23).

CHAIR OF CHEMISTRY at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

LECTURER IN THE DEPARTMENT OF PHILOSOPHY, Victoria University College, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

LECTURER IN GEOGRAPHY—The Secretary, The University, Aberdeen (September 5).

ASSISTANT REGIONAL TRIALS OFFICER (graduate in botany or agriculture, and preferably practical experience in crop production), at Leeds University Farm, Headley Hall, Yorks—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

CHEMIST (with a first- or good second-class honours degree in chemistry) with the Geological Survey of Uganda, for the analysis of ores, rocks and minerals with particular reference to the ores of tungsten, beryl, niobium and tantalum and analyses of limestones, and to work in close co-operation with the department's ore-dressing laboratory—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/9/06.

DEPUTY DIRECTOR OF RESEARCH—The Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22.

MASTER TO TEACH PHYSICS, including advanced and scholarship levels—The Headmaster, Bishop's Stortford College, Herts.

PHYSICISTS (with, or obtaining, a first- or second-class honours degree or equivalent qualifications) at Ministry of Supply Research and Development Establishments in the South Midlands and the South of England, for work directed towards the solution of problems and the development of new ideas in the fields of radio communications, radar, guided missiles, aircraft and aircraft equipment, gas turbines, instrumentation, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.214/6A.

PHYSICS LABORATORY TECHNICIAN, for duties concerned with the application of physics to medical problems, maintenance and service of electrical equipment, including high-voltage X-ray sets and electronic equipment used with radioactive isotope work—The Group Secretary, War Memorial Hospital, Scunthorpe.

RESEARCH ASSISTANT (honours science graduate), to work on the chemical and biochemical aspects of cancer research—The Director of Cancer Research, Department of Pathology, Medical School, The University, Birmingham 15.

RESEARCH OFFICERS (preferably with an honours degree in mining, metallurgy or chemical engineering and/or postgraduate experience) IN THE MINES DEPARTMENT, Federation of Malaya, for research into mining and mineral dressing problems and the application of results, through pilot stages, to utilization in the field—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.99/23/01.

SENIOR LABORATORY TECHNICIAN IN THE CLINICAL PATHOLOGICAL LABORATORY, for duties which will be mainly biochemical—The Secretary, The National Hospital, Queen Square, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Air Ministry: Meteorological Office. Professional Notes. No. 120: Distribution of Wet-Bulb Temperature at Aberdeen and Eskdalemuir. By A. B. Thomson. Pp. 26. (M.O. 524k.) (London: H.M. Stationery Office, 1956.) 1*s*. net. [64

Royal Technical College, Glasgow. Annual Report on the One Hundred and Fifty-Ninth Session. Pp. 64. Report on Research Session, 1954–55. Pp. 40. Department of Civil and Mechanical Engineering. Postgraduate Course in Environmental Control Engineering and Resource Utilization. Pp. 13. (Glasgow: Royal Technical College, 1955 and 1956.) [64

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Nuclear Engineering. Vol. 1, No. 1 (April, 1956). Published monthly. Subscription rates for 1 year: 42*s*.; U.S.A. and Canada, 7 dollars. Pp. 48+72. (London: Temple Press, Ltd., 1956.) [64

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Forestry Commission. Leaflet No. 10: Oak Leaf Roller Moth. Pp. 7. 6*d*. net. Leaflet No. 37: The Capercailzie. Pp. 10. 9*d*. net. Forest Record No. 30: Growth and Yield of Sweet Chestnut Coppice. By C. D. Begley. Pp. 25+8 plates. 2*s*. 6*d*. net. Report of the Committee of Hedgerow and Farm Timber, 1955. Pp. 64+8 plates. 3*s*. 6*d*. net. Report on Forest Research for the year ended March, 1955. Pp. viii+140+12 plates. 5*s*. 6*d*. net. (London: H.M. Stationery Office, 1955 and 1956.) [64

Annual Report on the Progress of Rubber Technology. Vol. 19, 1955. Pp. vii+158. (Cambridge: W. Heffer and Sons, Ltd., 1956. Published for the Institution of the Rubber Industry.) 21*s*. [124

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Iron and Steel Institute. Special Report No. 55: Physical Aspects of Absorptiometric Analysis—a Consideration of the Principles Involved in and Factors Affecting the Performance of the Hilger Photoelectric Absorptiometer. By the Methods of Analysis Committee, Metallurgy (General) Division. Pp. ii+37+4 plates. (London: Iron and Steel Institute, 1956.) 25*s*. (Members, 15*s*.) [124

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